

# SCIENTIFIC AMERICAN

## No. 221 SUPPLEMENT

Scientific American Supplement, Vol. IX, No. 221.  
Scientific American, established 1845.

NEW YORK, MARCH 27, 1880.

Scientific American Supplement, \$5 a year.  
Scientific American and Supplement, \$7 a year.

### THE MELBOURNE INTERNATIONAL EXHIBITION.

The building erected at Melbourne, the capital of the Australian province of Victoria, for the International Exhibition to be held this year, is now approaching its completion. The late Governor of Victoria, Sir George Bowen, laid the foundation-stone on Feb. 11, last year. We take the following description of the building from the *Melbourne Argus*:

"The building designed to contain the exhibits will be an important addition to the architecture of Melbourne. The site, in the Carlton Gardens, is an excellent one, and will show off the structure to advantage, and as, after the great show of next year, the building will be retained as a permanent exhibition building, the fabric will probably for many years be reckoned as one of the most striking ornaments of

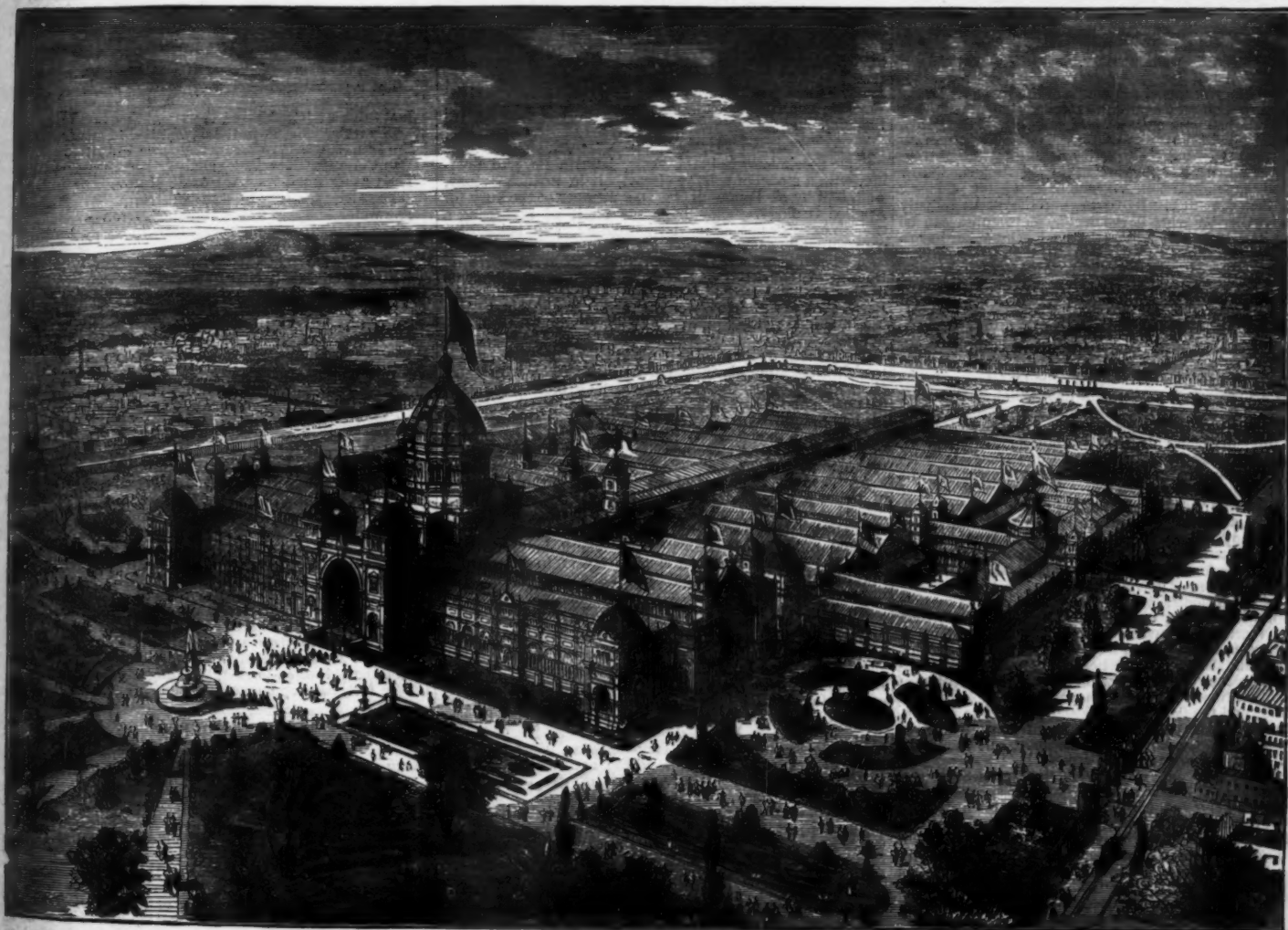
100 ft. square, but as its octagonal shape becomes defined the diameter is contracted to 60 ft.

"The rest of the building is in fine keeping with its main features and with the nature of its design, which may be characterized as Italian Renaissance. At each side of the central tower runs the nave, which from end to end measures, as we have already stated, fully 500 ft. The exterior walls are, however, not those of the nave, but of the courts which are built alongside them—an arrangement which accounts for the way in which the windows are designed. The architects are, indeed, well deserving of credit for the fact that they have wholly dispensed with skylights as unsuited to the climate, and always more or less actively productive of inconvenience to every one beneath them. Thus the courts are lighted through the exterior walls, the lower by windows intersected by columns, the upper by a clerestory

adapted for the display of certain classes of goods; and the upper courts, which correspond, of course, with the galleries inside the nave, are specially suited for the exhibition of pictures or sculpture. The material of the building is brick, stuccoed. The roof will be of iron, or wood and iron."—*Illustrated London News*.

### APPLIED SCIENCE EXHIBITION, PARIS.

In consequence of the acceptance by M. Cocheron of the portfolio of posts and telegraphs, M. Jules Simon was appointed President of the Superior Commission, and duly opened the Exhibition in the Palais de l'Industrie, on the 24th July, the date originally fixed. On account, however, of the building having been cleared of the pictures and statuary of the *salon* only a fortnight previously, the ex-



THE MELBOURNE INTERNATIONAL EXHIBITION.

Melbourne. The design is the work of Messrs. Reed & Barnes, the architects of many of our leading city structures. The salient features of the building (which will be the largest Melbourne has yet known) will be, first, a dome higher than the highest spire in the city, flanked by a number of smaller towers of pavilion shape; and, secondly, a variety of ornamental details, mostly in such high relief as must entirely prevent the dead-wall effect but too frequently conveyed under similar circumstances.

"The building, excluding the temporary annexes for machinery, etc., is cruciform, consisting of a nave 500 ft. long, running from east to west, and cut through its center by a transept 270 ft. deep, the ends of which are north and south. This transept is the leading feature of the fabric. At its south end is the chief portal—a tall arch 40 ft. wide and 60 ft. high, deeply recessed, and reached by a flight of broad stone steps. On each side are square towers 105 ft. high, adorned by picturesquely-shaped and well-grouped windows, together with Ionic pilasters and enriched panels. The north end of the transept is arranged on almost precisely the same pattern. Some 50 ft. behind the portico, and at the point where the transept intersects the nave, rises the dome, octagonal in form, and reaching the height of 93 ft., itself above the main roof it is surrounded by columns, dividing groups of windows, and just above that point the spire gradually begins. At its base the central tower is

of the same pattern in small just beneath the parapet. The roof of the nave, rising above the parapet, affords room for the clerestory, by which the great space below is lighted. In this way the sun's glare is excluded, and a capital means of ventilation afforded. To intercept further heating rays of sunshine and also get rid of everything in the shape of dead-wall effect, there is between each window of the main building a species of buttress standing out a few feet.

"Finally, the exterior of the building may be said to be completed, and its outline rendered most agreeably impressive, by a pavilion tower, 80 ft. high, at each corner. The interior, as it will strike the visitor, may be briefly described. Entering the building by its south and chief portal, he will at once face the noble transept, 70 ft. high, 60 ft. broad in the clear, and, besides, flanked with side galleries, covering an additional space of 20 ft. wide. He passes on some 50 ft. further, and then finds himself beneath the open dome, and at a point from which branch not only the 270-ft. long transept, running north and south, but the nobler and grander nave, the dimensions of which are truly vast. It is 500 ft. long, 70 ft. high, and, with the galleries, which correspond with those already described, fully 100 ft. wide.

"The vistas thus afforded will constitute to those who have never seen one of the great exhibition buildings of the world a perfectly unprecedented sight. Between the nave and the outer walls on each side are several courts, each 300 ft. long and 30 ft. wide. They will be found admirably

adapted for the display of certain classes of goods; and the upper courts, which correspond, of course, with the galleries inside the nave, are specially suited for the exhibition of pictures or sculpture. The material of the building is brick, stuccoed. The roof will be of iron, or wood and iron."—*Illustrated London News*.

### MINING AND METALLURGY.

The Diamond Rock Boring Companies of London were

awarded a silver-gilt medal for a collection of fifty cores, or cylindrical specimens of rock, brought up by their annular drill, set with black diamonds, from various depths to 1,400 feet. They vary in diameter from  $1\frac{1}{2}$  to 11 inches, and also in length; but one specimen was raised entire about 9 feet long. They were selected from as great a variety of rocks as possible, including coillite, limestone, anhydrite, gypsum, sand-stone, loam clay, and even rock-salt and potash-salt, in order to prove that actual specimens may be obtained from all strata by this system of boring. With the exception of one core, from the well at Messrs. Meux's brewery, in the Tottenham-court-road, all the specimens were obtained from Ascherleben, in Prussia, where the continental branch of the company proved the existence of valuable potash-salt deposits, which have been turned to account as manure in reclaiming waste lands.

MM. Louis Favre et Cie., the contractors for the St. Gothard Tunnel, exhibited a whole set of plant, including an air compressor and carriage mounted with the six varieties of rock drill employed, which had actually been at work in the tunnel. These were only worked occasionally on account of the great amount of power required to drive them; but a highly finished model of turbine, compressor and carriage with two drills, was frequently set to work on a piece of granite brought from the Göschenen end of the tunnel.

The Société Française Anonyme du Nickel, Paris, which has been formed with the co-operation of M. Garnier, to import and smelt the ore discovered by him in New Caledonia, exhibited a large block of nickel ore, to which the name of "Garnierite" was given by English and American geologists, in honor of its discoverer. They also showed ingots of pure nickel, and of an alloy, half nickel and half copper, more easily dealt with by foundries, besides a great variety of manufactured articles, cast, rolled, or beaten out of white nickel bronze. Their object was to prove that the same articles which are now made of brass or copper, nickel plated, may be produced in solid nickel bronze, by the same plant and processes, and at practically the same cost, with the advantage of being the same throughout their substance and of being easily kept bright.

#### MACHINERY.

The machinery occupied the whole of the space under the south gallery, along the center of which a line of shafting in two lengths had been erected by M. Rikkers, of St. Denis, who also supplied the motive power. The boilers were all of the vertical type, but their distinguishing feature is that the water tubes, which hang down into the firebox, follow mainly the shape of the letter U, one branch being of larger diameter than the other. By arranging the tubes radially with the smaller branches in the center, more tubes can be got into a smaller space; and as the smaller branches have a larger heating surface in proportion than the larger, and are, besides, exposed to the most intense heat of the furnace, the circulation is very active. The engine that drove the larger portion of shafting is of novel design, and gave off 98 per cent. of the theoretical effect. The double piston rods of two horizontal cylinders, placed face to face, are connected by a cross head, and work direct on to the crank pin without any connecting rod.

M. Goubet, St. Denis, showed a method of transmitting power by a shaft out of the straight line, which he effects by introducing a universal joint into the shaft. A practical application was shown in a model of steering gear for vessels, the propeller being placed in the middle of the rudder, which can be made to form an angle of 90 degrees with the main portion of the shaft without interrupting its revolution.

M. Emanuel Farcot, Paris, showed in action a new dynamometer of his design and construction, by which the power absorbed by any machine may be ascertained at once by means of weights on a scale beam. He also showed a new lamellar injector for feeding steam boilers, and a centrifugal fan, as to which he has a new theory.

The Société de Construction de Passy had erected a whole set of milling machinery on the Hungarian system, by which the corn is crushed between steel rolls instead of being ground by stones in the usual way. The advantages of this system are that the flour is not heated in passing momentarily through the rolls as it is while being ground between stones, so that the flour runs no danger of being converted into starch; and the flour is whiter and of a better quality, owing to the absence of fine particles of bran, which, in stone grinding become mixed with the flour, and cannot be removed by any known process.

Appliances for raising water were very numerous; and two of them are quite new and original. M. Lagogue, of Paris, showed his "pulsateur," in which steam is utilized in a two-fold manner; it first forces the water upwards through the delivery valve by pressing on an India-rubber diaphragm, and then, on being condensed, causes a vacuum, to fill which, some more water rushes up from below. M. Duden Mahon showed in action his "balancier hydraulique," by which, with a fall of 4 ft., water may be raised to any height. Two chambers are mounted on the ends of a beam, like the bell crank of mining pumps, to which the pump rods are connected; and these being alternately filled and emptied while the valves open and close automatically, cause the beam to oscillate, and thus work the pumps. MM. Bichon et Cie., Paris, showed the new Keiser pump, specially intended for emptying the cesspools of Paris and other large towns in France. It is provided with new joints by which it is quickly and easily connected to the hose pipes, and also with India-rubber lip valves, something like those of Perceux, for allowing corks, broken bottles, and other extraneous substances to pass freely. It is mounted on a pair of wheels and worked by a lever. This firm also showed in action their new saw sharpening machine. A circular file in the shape of a bevel edged disk, makes a few revolutions to effect the sharpening of a tooth, and then, owing to an ingenious arrangement of the gear, stops while a wiper on the fly-wheel acts on a pawl, which causes the saw to move onwards the space of a tooth. Straight saws travel along in a kind of slide-rest, circular saws revolve on a horizontal spindle, and band saws pass round a pair of flanged horizontal pulleys. M. Martinier, of Cognin, Isère, also sent a saw sharpening machine; but, in this instance, a triangular file, mounted on an articulated parallelogram, is moved forward by a cam, which also raises it from the saw during the return stroke.

MM. Th. Dupuy et Fils, Paris and London, received a gold medal for their compressing machine for making bricks, briquettes from coal dust, and other conglomerates. Its distinguishing feature is that the degree of compression can be altered in the same machine to suit various substances to be conglomerated. This is the machine that is used by the Eastern Railway Company, of France, for mak-

ing briquettes from the waste fuel of locomotives.\* M. Fleury showed in action a continuous brick moulding machine, in which the moulds, arranged in a circle, constantly revolve in a horizontal plane. The clay is fed into them just in front of a heavy conical roller; and the bottoms of the moulds rise so as to throw out the bricks when moulded, and then fall again ready to receive more clay. M. Jannot, Paris, sent a combined grinder, mixer, and elevator, in which springs allow the rolls to rise when encountering too large an obstacle, and revolving scoops raise the crushed material and allow it to fall on to a conical riddle in the center.

MM. Gary Frères, Paris, showed a manual stone sawing machine, which consists of an ordinary stone saw, mounted in a frame, and made to move backwards and forwards by a crank and connecting rod from a fly wheel and handle. A depth of 6 ft. in soft stone, and 6 in. in hard, is cut in an hour; and one man with the machine can do as much as four without it, while the surface of the sawn stone is more regular. M. Thiersot, of Paris, sent an improved fret saw, with an elastic arm composed of plate springs, with the addition of spiral springs for still greater elasticity. M. Romary, also of Paris, showed an originally designed band saw, worked by a jointed triangular pedal, with gearing to increase the speed. The canting table is held by two grooved semi-circular plates, which permit of the table being cut with an inverted V to allow the passage of the saw; and yet leave no space at each side of it on the upper surface of the table.

Machine made lace is woven in a piece composed of several breadths, which are afterwards separated by hand with a pair of scissors. This tedious operation is rendered unnecessary by the treadle scalloping machine of MM. Lebœuf et Deschamps, which separates the breadths of whatever pattern the edge may be.

In the Machinery Hall were shown specimens and applications of a remarkable substance prepared by Señor Unciti, of Barcelona, and said to be grease deprived of one of its constituents. It is claimed to act as a good lubricant, to remove boiler incrustations, and prevent further incrustation with all waters; to prevent boiler plates from burning, and hasten the generation of steam; and, finally, to prevent the oxidation of iron and steel articles which have remained coated with it for 24 hours. Practical demonstrations of some of these qualities were given in the Exhibition and its annexes; and further experiments are now being made in England.

#### BUILDING.

Some specimens of pillars, vases, balustrades, and flooring, with a model of spiral staircase, all in artificial stone, were sent by M. Dumesnil, Paris, a member of the Jury for Applied Geology. They have the merit of possessing a smooth exterior not affected by weather, and being of a cheerful white color all through the substance. A system of fire-proof floors was sent from the Grande Tuilerie de Bourgogne, consisting of hollow red tiles, forming segments of an arch, supported on rolled joists. M. Perrière, mason, Paris, showed a somewhat similar arrangement, but in this case moulded slabs of plaster with longitudinal cylindrical holes were supported by the iron joists.

M. Quincel, a zinc worker, Orsay, Seine et Oise, sent a model, illustrating his system of covering roofs with sheet zinc, without nails, the heads of which are broken off by the expansion and contraction of the metal. The method is simple and practical, permitting the sheets to be easily removed for repairs to the roof. The Société des Forges de Montataire showed their "metallic slates" of galvanized iron for the same purpose.

An ingenious arrangement for supporting the centering of arches was shown by M. Camusat. It consists of a cylindrical box of sheet iron, provided with several holes near the bottom stopped with plugs. The uprights are supported by sand, rammed into the box; and when it is required to strike the centering, all that is necessary is to remove the plugs when the sand runs out, and allows the uprights to drop.

#### LIGHTING AND HEATING.

During the dark afternoons, before the close of the Exhibition, the machinery department was illuminated by the electric light apparatus of Messrs. Siemens Bros., and MM. Lontin et Cie.; and the Oriental Court was lighted up by air gas, made by carburizing atmospheric air with petroleum spirit at 680 degrees in the apparatus, including a heater of M. Albert Lascols, Paris.

MM. Jousseume Frères, Ivry-sur-Seine, showed specimens of gas retorts, coated within and without with a special cement which prevents loss of gas through the pores of the fire clay, and also the adhesion of particles of the graphite which is usually deposited to the diminution of the capacity of the retort. M. T. Schreiber, Saint-Quentin, erected some small gas works in the annexe, with special retorts for distilling gas from boghead, wood, cork waste, fatty matters, heavy oils, and the residue of petroleum. He made the gas on the spot with various substances, and burnt it in one of the new lamps brought out by the Compagnie Parisienne du Gaz. This lamp has six ordinary burners, the flames of which impinge upon each other and form a corona, causing such intense heat as to greatly improve the combustion, which is further aided by draughts of air directed by an internal and external glass just on to the flame. A small protected jet is constantly burning for lighting the rest without opening the lamp; and there is also a single burner above the rest for use when the full light is not required. The Rue du 4 Septembre, and other streets in Paris, have been provided with these lamps (each of which gives a light of 140 candles), by way of competition with the electric light.

Heating stoves in great variety were exhibited, some of them in action during the cold days toward the close of the Exhibition. In one of them, unprovided with a chimney, it is pretended that the carbonic acid is condensed in a pan of water. The "movable stove," Place de l'Opéra, Paris, runs upon three wheels, and has a short up-turned pipe, so that it can be wheeled about, ready lighted, from room to room, the pipe being placed under the chimney without any fixing. It is said to keep alight for twelve hours without attention, and to be capable of regulation so as to burn from 15 to 40 liters of coke a day. The "Calorifère Phénix" of M. Peyre Gough, Paris, is a slow combustion stove, with an inverted hollow cone, closed at the top with a cover set in sand to make a tight joint, and surrounded by an outer case. A fire is lighted at the bottom of the conical receptacle, which is then filled with small coke; and combustion goes on at the bottom only until all the coke is consumed. M. Bertrams, of Paris, showed several specimens of his sheet

iron bends for stove pipes, made by puckering up the inside of the bend, while the outside is quite smooth.

M. Wery, Paris, showed in action his smoke consuming chimney for furnaces and steam boilers. He admits air at suitable points in the chimney, for causing the combustion of the colorless gases and a large portion of the smoke, whereby he claims to effect a saving in fuel from 25 to 30 per cent., according to its nature, and to obtain an equal draught with one-fourth the height of chimney.

A new *chauffe-pied*, or foot warmer, was shown by MM. J. Lefranc et Cie., Paris, which has been adopted by the leading cab companies of that city, and also as far as their existing arrangements would permit, by some of the French railway companies. It consists of a sheet iron box of the usual shape, covered or not with carpet, and provided with a sliding drawer, over which the air can pass freely through holes in the ends. *Briquettes* of pure and highly compressed carbon are made from a mixture of coke, peat, and spent tan, to which some chemical substances are added. When required for use, one of these is raised to a red heat in any fire, then exposed to the air for a second or two, that it may part with the sulphurous fumes it has taken up from the coal, and then inserted in the drawer, where it will continue burning for 14 hours in a carriage, or 16 hours in an apartment, until the whole is consumed, giving out no objectionable odor.—*Journal Society of Arts.*

#### MODERNIZED VERSION OF THE OLD OAKEN BUCKET.

MR. J. C. BAYLES, in the *Sanitarian*, gives the following revision of the popular song of "The Old Oaken Bucket," which, we fear, has more of truth, if less of poetry, than the original:

With what anguish of mind I remember my childhood,  
Recalled in the light of a knowledge since gained;  
The malarious farm, the wet, fungus-grown wildwood,  
The hills then contracted that since have remained;  
The scum-covered duck-pond, the pig-sty close by it,  
The ditch where the sour smelling house-drainage fell;  
The damp, shaded dwelling, the foul barn-yard high it,  
But worse than all else was that terrible well,  
And the old oaken bucket—the mould crusted bucket—  
The moss-covered bucket—that hung in the well.

Just think of it! Moss on the vessel that lifted  
The water I drank in the days called to mind,  
Ere I knew what professors and scientists gifted  
In the water of wells by analysis find.  
The rotting wood-fiber, the oxide of iron,  
The algae, the frog of unusual size;  
The water—impure as the verses of Byron—  
Are things I remember with tears in my eyes.

And to tell the sad truth—though I shudder to think it—  
I considered that water uncommonly clear,  
And often at noon, when I went there to drink it,  
I enjoyed it as much as I now enjoy beer.  
How ardent I seized it with hands that were grimy!  
And quick to the mud-covered bottom it fell;  
Then soon, with its nitrates and nitrites, and slimy  
With matter organic, it rose from the well.

Oh! had I but realized, in time to avoid them,  
The dangers that lurked in that pestilent draught,  
I'd have tested for organic germs and destroyed them  
With potassic permanganate ere I had quaffed;  
Or perchance I'd have boiled it and afterward strained it  
Through filters of charcoal and gravel combined,  
Or, after distilling, condensed and regained it  
In potable form, with its filth left behind.

How little I knew of the dread typhoid fever  
Which lurked in the water I ventured to drink!  
But since I've become a devoted believer  
In the teachings of science, I shudder to think.  
And now, far removed from the scenes I'm describing,  
The story for warning to others I tell,  
As memory reverts to my youthful imbibing,  
And I gag at the thought of that horrible well,  
And the old oaken bucket, the fungus-grown bucket—  
In fact, the slop-bucket—that hung in the well.

#### EFFECTS OF A THUNDERSTORM ON A TELEGRAPH LINE IN NEW ZEALAND.

By W. H. FLOYD, M.S.T.E., Superintendent of New Zealand Railway Telegraphs.

ON the afternoon of the 11th of November, this year (1879), a violent thunderstorm was experienced on the Malvern branch of the New Zealand system of railways in the Middle Island, and considerable damage resulted to the railway telegraph line between Darfield Junction and Hawkins Stations.

Nine telegraph poles were more or less damaged, and six of them were so badly shattered and splintered as to be no longer serviceable; the remaining three, although considerably shaken, were good enough to be refitted and continued in use as telegraph poles. The damage to poles extended over a straight line of three-quarters of a mile in length, but all the poles in that length were not injured.

Commencing three-quarters of a mile from Darfield Junction, the first pole was badly shattered, and only about a third of it left standing, the other two-thirds being split up into small fragments and scattered about. The next pole toward Hawkins Station was perfectly sound. The third was as badly injured as the first, but the fourth and fifth were uninjured. The sixth, seventh, and eighth were badly shattered and splintered from their tops to the ground line.

Between the seventh and eighth poles, at about the center of the span, and also at about midway between the first and the last pole injured, the telegraph wire of No. 8 gauge was fused and parted, and over the whole of the 21 feet distance between the line of wire and the railway metals the ground showed signs of disturbance. Three railway sleepers were shattered, and between one of them and the line of wire there were two strongly-marked paths, resulting from the storm. The paths were joined just at the sleeper, but divided almost immediately, and remained distinctly separate until they disappeared altogether—6 feet apart—directly under the line of telegraph wire. It appeared as though there had been an independent path made between each separated end of the fused wire and the railway metals.

The paths were tunneled part of the way to a depth of from 12 to 15 inches underground, and to a diameter of about 5 inches, and part of the way they were cut to a depth of from 4 to 5 inches from the surface. The earth thrown up at the sides of the surface cuttings exhibited, in patches, a grayish

\* See "Utilization of the Waste Fuel of Locomotives," No. 1,394, p. 608.

color that suggested the idea of its having been under the influence of fire.

The ninth pole had only a piece of its top splintered off, and could be refitted. Between this pole and the railway there was a single path, partly tunneled and partly out from the surface, as previously described. In both cases the disturbance of the ground was greatest near the railway, and gradually decreased until it ceased altogether under the line of telegraph wire. The tenth pole was only slightly shaken near the ground line. The eleventh had a slice two inches thick cleanly taken from under its arm to the ground line, and the slice was splintered into matchwood. The next three poles were uninjured, and the signs of damage ceased altogether at the fifteenth pole, which was badly shattered. None of the poles were provided with lightning conductors.

At the Darfield Junction telegraph office the station master and telegraphist were seated writing, when they saw a bright light apparently leap from one of the instruments to the floor, and heard a noise like the report of a fowling-piece.

The instruments remained in working order, but it was afterward found that the local contacts of a Siemens polarized relay showed signs of the lightning. Part of the surface of the platinum contact piece on the armature was fused, giving the appearance of a circular space about one-eighth of an inch having been tooled out of it in a lathe, except that the bright surface inside the circle had minute glistening feathery particles of platinum left on it; and the platinum point, with which the piece on the armature makes contact to complete the local circuit, had a roughened and discolored appearance, due to its surface having been fused.

The glass top on the relay was also spotted just above the local contacts with innumerable dots that had a bright metallic appearance under a magnifying glass. These spots were much brighter and more clearly defined on the inner than on the outer surface of the glass top of the relay.

The Darfield Junction office was fitted with Siemens grooved-plate lightning guards, placed between the leading-in wires and the instruments.

### A COLORADO GLACIER.

A GENTLEMAN who has during the last two years traversed the mountains around Leadville, and penetrated almost every one of the secret recesses, informs a *Herald* reporter that there is within twenty-five miles of this city one of the most interesting curiosities of nature—a veritable glacier, presenting all the characteristics of the glaciers of Switzerland, both in magnitude and motion, its progress being gradually down the gulch. The scene of this curiosity is located in the Mosquito range, about fifteen miles north of the pass. Our informant says that he first discovered it about three years ago, while out on a prospecting tour. It was then about a mile in length, and at the bottom of the gulch presented a sheer precipice of ice not less than one hundred and fifty feet in height. Later in the season the place was visited again, and it was found that the great mass of ice had melted until at its face it was not more than one hundred feet high, the loss from the surface reducing its length to about half a mile. Again, early the following year, the place was visited, and the glacier was found to have regained its bulk, showing that the accumulation of ice and snow during the winter was about one-third its gross bulk. The rocks on the side of this immense mass of ice shows the marks of attrition, proving beyond all controversy that the glacier is in motion. Indeed the earth at the foot of the glacier heaved up in great masses shows that it is gradually moving down into the valley. During the summer a large stream of water flows from the face of the icy cliff. Our informant is of the opinion that the glacier, as it progresses out of the deep gorge in which it was formed, will slowly melt away, and that it will not last many years. It is out of the way of ordinary travel, and the route to the scene is exceedingly difficult, so that it is not likely to be visited except by prospectors and hunters.—*Leadville (Col.) Herald*.

### AN AMERICAN COTTON MILL.

THE GREAT BOOT COTTON MILLS AT LOWELL, MASS.

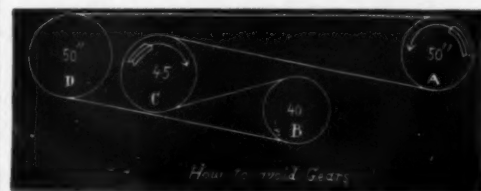
THE Boot is one of the oldest corporations in Lowell, having been incorporated in 1835, and commenced operations in 1836. It has six mills, with three thousand looms, employing nearly two thousand operatives, and makes a very large variety of goods. The special reason of our choosing this corporation as a subject for the present sketch, says the *Boston Journal of Commerce*, was because of the changes made during the few years under Mr. Cumnock's management, in which is embodied the economical use of power, both water and steam, and the application of steam to the various demands of the mill, such as heating, sizing, yarn, vapor, and the various other little uses; not that there is anything quaint or peculiar in his method, but that in his application he has sought to embody the economy of fuel and safety, together with the best mode of doing everything. This article then will treat more particularly of the application of power, the transmission of power, the management of the enormous amount of power used by this concern, and the connecting of water and steam, with all the various changes liable to occur during different stages of water and weather.

The power of the mills consist of nine turbine wheels and a double Corliss engine of 1,000 horse power, making all told between 3,300 and 3,500 indicated horse power. The water wheels are in different positions, several hundred feet apart, while the mills are all run as one, and the power is really a unit or connected. How this has been done, and how it is working, how all the variations caused by excess of water, lack of water, anchor ice and back water, and how it is governed, etc., is one of the purposes of this article. The water wheels are all run at full gate, whether the fall is higher or lower. The steam engine regulates the whole concern, doing at times 300, 300, then 500, and so up to fully 1,000 horse power, depending very much upon the condition of water in the canal and in the river. That this can be done practically, without smashing of gears, water wheels, or shafting, is owing to the fact that it is all controlled by one man, who can, by means of simple signals, using the telegraph, stand at his engine, communicate and receive an answer instantly from the different men in charge of the wheels; or, in case of accident, men in any department of these six mills can tell the engineer there is trouble, and give him the signal to stop without any inaccuracy, risk of breakage, or confusion; and that this concern, with a combined power of nearly 3,500 horses, can be brought to a standstill in less than sixty seconds, even when no one is expecting the signal, has been demonstrated and can be done at any time of the day. To those who are using large amounts of power this may seem very strange, but this is only one of

the advantages Mr. Cumnock has wrought out for his company, as will be seen further on. The data which is here given was taken while traveling over the concern; the dimensions, sizes, speeds, and statistics were all given us freely and fully, and will certainly prove a matter of interest to our readers.

In the No. 5 mill is the center of power. There are two Swain wheels, 73 inches in diameter, 18½ feet fall, 340 horse power each. The belt pulleys, which transmit the power of these two wheels, are five wheels 14 feet in diameter, made by the Ames Company at Chicopee, and are of iron with double faces, one having a 24-inch and 30-inch face, the other having a triple face 24, 30, and 20. These belts connect with a steam shaft four and one half inches in diameter, which is driven by and from the engine, which is some six or seven hundred feet distant. The power, engine, and wheels are connected here, and distributed right and left. Gauges are also here which show the height of water in the river as well as in the canal, so that the men can be guided as to the head and fall. The regulating apparatus is so connected that it shows instantly whether the wheels are working fast or slow, without waiting to watch to see them work. The speed is shown by a glance at the dial. In connection with these wheels there is an eighty-inch Swain and four ninety-inch Boydens, and a thousand horse engine. These are what may be termed the permanent power. They have also a reserve of two ninety-inch Boydens, used only when there is high water, or to run whenever the water is low. There is an electric alarm in all the wheel rooms, whereby any one in the rooms can, by the electric apparatus and simply turning a key, make two taps upon the gong, which means shut down or stop at once without asking any questions or waiting for instruction. In starting the water is put on, and the engineer waits until the power is on before putting on the full power of his steam engine. Whenever the water is all on the engineer puts on steam to bring the whole mill to power. In starting the mill this requires some three or four minutes. It is the custom of the Lowell mills to start their mills five minutes before the regular time, and thus four minutes is used in regulating and getting enough motion. This is all the overtime that any of the Lowell mills run. Besides the regular electric line alluded to, there is a private line connected with each wheelman's station, at the various points, in direct connection with the engineer, and he in turn with them. They are called and answered without leaving their places, and in case of accident, variation of speed, or anything else which occasion requires, each can at once communicate with the other. The speed can be made faster or slower, and anything which may arise is provided for by instantaneous question and answer by electricity, saving all confusion and yet acting with certainty. The man at the wheel can ask the engineer questions, or tell him what is being done in his wheel room by the simple taps of the bell, and receive from the engineer instant answer and directions, neither man losing sight or sound of his room.

Leaving the wheel room of No. 5 and all its connections—which, by the way, is in charge of a man who is stationed here, but who has something to do besides watching the wheels, as he has charge of mending or repairing the belts—we started for the engine room, stopping, however, to look at what to us is a mechanical curiosity, and a very sensible one too, in the connection between Nos. 1 and 2 and No. 5 mills. Here, between another wheel pit and the one we have just described and the engine, is still another connection. There are running through it two twenty-two-inch belts, traveling at the rate of 5,100 feet per minute. The shafting in No. 5 mill runs against the sun, and in Nos. 1, 2 and 6 mills, the shafting runs with the sun. This requires a reverse motion, if the same belt is to do the work. The belt is led from the engine shaft from No. 5 through and under the connections to Nos. 1, 2, and 6 mills.



Our engraving shows how this has been done. The sizes of the pulleys are given, also the direction in which they run, and how the belt leads from the 50-inch pulley, does its work, and returns again. The 50-inch pulley is in one mill, while the forty-five and fifty are in another; one fifty and one forty are used as carriers simply, while the forty-five is driven by the fifty, the 50-inch running one way and the forty-five-inch running the other, an open belt being used to do the work. We have called this "How to Avoid a Pair of Gears." In the wheel room of Nos. 1 and 2, we noticed that the man in charge of the wheel was a carpenter, and was working within sight and sound of his gong. In the basement of Nos. 1 and 2 mills is a contrivance where, if Nos. 1, 2, or 6 require to be stopped, there is an apparatus where a man can, after giving the engineer the signal, throw off the entire power without stopping the engine or making any inconvenience anywhere, by simply shifting the 20-inch belt from a taut to a loose pulley. This is done by one of the simplest of mechanical contrivances. At the end of this shaft where this 20-inch belt is, there are two 23-inch pulleys, one on either end, going up into the mill; these pulleys are driven by the engine entirely. The two 23-inch pulleys drive up into the mill connected with the pulley from the water wheels, and in order to balance the power the main shaft is cut into four sections, with rings between the couplings, representing about 40 horse power for each section. When the agent finds this 20-inch shipping belt is working too hard, he goes up and adds an additional section to the engine by coupling an additional section taking 40 horse power from the water wheels, putting it upon the engine, or taking it from the engine and putting it on the wheel, as is required. If the water is low in the river and the wheels are developing more power, they throw more upon the water wheels by an additional section; if the water is high and the water wheels are retarded, the section is taken off and put upon the engine, so that the 20-inch belt is simply to keep the power regular.

From this we enter the engine room, where there is a Corliss engine, 30 inches by 60, condensing, double cylinder, running 60 revolutions per minute, with a fly-wheel 27 feet in diameter, 90 inches on the face, and a heavy balance wheel. The fly-wheel is boxed in on the rim, and contracted to the arms, in order to save all possible power.

The engine can be used high or low pressure, or partially high and partially low. The exhaust steam is used for slashing, heating vapor pots, and the various requirements of the mill. Two 28-inch belts and one 24-inch belt are connected with the engine and mill. These regulate the whole concern. The engine room is very handsomely finished up in natural wood, and all is very nicely done. The shaft driven by the engine runs 400 revolutions per minute; the pulleys are driven over a carrier pulley, so as to make the belt cover all the surface of the receiver that is possible. Two 28-inch belts run a steel shaft 4½ inches in diameter, 790 feet long. The other shaft is 3½ inches in diameter, also of steel, runs 400 revolutions per minute, and is connected with the two 28-inch belts which drives Nos. 1, 2, and 6 mills.

One thousand horse power is done by these two shafts. The 4½-inch shafting at the time we saw it had about 600 horse power upon it. We asked the engineer how he knew so long a shaft was in line. He took a hard wood stick, about 1½ inches square and 18 inches long, and putting the end of it behind one of the nuts of the pulley block he took a leverage on the end of the shaft from the pulley block and under the shaft itself; taking hold of the other end by his hand, he moved the shaft at least one inch endwise in its bearing several times, until we were entirely satisfied that it was very nicely put in its bearing.

The usual steam pressure under which this engine works is 90 pounds; the vacuum at the time we saw it was 27 inches. This engine is made with the condenser between the two cylinders, with the pump on the outside left hand engine, as you stand facing the engine in front. All the condensing connections are in between the cylinders, and the high pressure ends are upon the outside. If they require to run the engine high pressure it is simply a question of opening and shutting the valves inside or outside, all of which can be done in a few moments whenever the engine is still, either in the morning or at noon. Under the slasher room floor is a one and one-half inch pipe, with a Locke regulator, and this regulator is set so that whenever the back pressure is three pounds it will open and admit live steam, and will not permit the back pressure to go below three pounds. In the engine room is a gauge which gives the back pressure, and upon the engine which runs high pressure there is a right and left hand screw which shortens or lengthens the cut-off, and by that means the engineer can regulate the flow of steam into the high pressure end of the cylinder. The escape valve is weighted at six pounds. No steam can blow off if the engineer contracts the exit by holding it at four pounds. In making this change the other end of the cylinder will do more work, for there is margin enough for economy, as the engine is arranged to admit of it.

Between the engines upon the connecting rod, from the regulator upon one engine to the cut-off valves of the other, there is an arrangement of a balanced lever with a half-pound weight hung upon each end of it. Moving this little piece of iron makes the entire change of the number of revolutions of every spindle upon the whole 2,300 horse power. The leverage is changed out or in as may be required. Here is the application of the telegraph, both general and private: While standing here the agent asked a man 790 feet away from us, by three strokes upon the electric gong, "Is everything all right?" In seven seconds came back, "All right." Then by two strokes, "Have you trouble of any kind?" instantly the reply, "All right." Again, one stroke, "We are all right here," and instantly came the answer, "All right." Immediately after starting up the man in the wheel room of each mill strikes his number as 1, 2, 3, 4, 5, or 6, and then, "All right." One stroke, "I am all right, water is all on;" two strokes, "I am in trouble, send a messenger;" three strokes, "Are you running speed?" These are private line signals. On the main line two signals, if running, mean "Shut down." Then, without asking any questions, steam and water are shut off, and usually in less than one minute all is still. When stopped, two strokes mean "Start up." Then each of the wheel men know precisely what to do and when to do it. After the power is put on and the wheels put in motion, everything is then done over the private line.

When one comes to consider that the power here is scattered some seven hundred feet apart, and really all connected, a practical man will at once perceive the very great utility of this application of signals, by which every man stands at his post ready to act instantly, so that in case of breakage or accident, the signal can be telegraphed to the engineer from any part of the mill, and he instantly gives his orders to the men in the different wheel rooms, to each one in the same instant of time. He has then simply to shut off his steam, and in the time we are writing it the six mills are still.

From the engine room we proceed to the fire room. Here are seven steam boilers, seven feet in diameter, and seventeen feet long, of the horizontal tubular type, which have been recently put in. On another nest in the same room, are six boilers four feet in diameter, and seventeen feet long, made of the best fire box iron, and of the same horizontal tubular type. Each of these boilers is furnished with water gauges, low water alarm (Fairbanks' patent) with fusible plug, a gauge glass, and a steam gauge upon each boiler. Every boiler is fed separately and has a stop chuck in the pipe. No two boilers are fed from the same pipe, and the feeding apparatus is a Hancock inspirator; a large one is used during the day, No. 50, and when the engine is still, and at night, a No. 35 supplies them. The water runs from the hot well through two Robinson water heaters. One of these heaters is heated by the slasher water and steam. No. 2 heater is heated with exhaust steam, and it runs from No. 2 into No. 1, and then into a hot well. The feedwater by this arrangement is frequently used or fed into the boiler at from 236° to 240° F. Thermometers are set in three different places in the feedwater pipe and about the heater, so that the readings can be taken at any time by a simple glance. Everything is done that can be to insure the safety of the lives of the men in charge, as well as those who are over, around, or near them, and with a view to service and economy. Since the advent of the slasher size machine, very much trouble has been encountered, and ingenuity exercised in endeavoring to do the most with the least amount of steam, especially since it was found that the slasher machine would work just as well with exhaust steam blowing through the cylinders; but how to do this economically has been a question.

From the boiler room we went into the slasher room, through the "drawing-in" room, where 35 women are employed in simply "drawing-in" the warps for these mills. There are eight slashers at present at work, and one or more are soon to be added. The apparatus used is described as an eight inch exhaust pipe, and supplies the steam from the engine. Each slasher has a three inch pipe running from the exhaust pipe, and branching off from it is a 2½ inch

pipe to each cylinder of each machine. The connections are full size,  $\frac{3}{4}$  inch; no nipples down or reductions being used. Upon the other side there is a double set of connections with one running. Live steam traps are used on the opposite side from where it enters when running exhaust. The steam is blown right past the traps into the No. 2 heater in the boiler room, and then it is used to heat water as well as drying yarn. Upon the feed side of the slasher there is a connection for high pressure and low pressure as well, so that in any event one or the other is always accessible, and no difficulty can be had even for one moment. The high pressure cannot be used without consulting the overseer of the room. The high pressure is kept away from the low pressure by a lock regulator which is always locked.

The sizing apparatus of the Boot mills is not only a curiosity, but in point of economy and distribution, perfection of work, etc., we do not know of anything of the kind in this country; still it may exist. The sizing is made by boiling in two 400 gallon boilers, and as fast as it is wanted. It is taken into a tempering tub with a jacketed bottom, heated by exhaust steam passing through it, which keeps the size at a uniform temperature, without coming in contact with the moisture of the steam. From this box it is pumped mechanically into the sow boxes of the slasher, where it is kept boiling by closed steam pipes, not by jets of steam being distributed into the size. These boiling tanks are situated in the next story below the slasher room. One man makes all the size, tempers it, keeps it pumped up; any surplus size comes from the sow box back down into this tank again. No one of the men is allowed to use water or steam in connection with his size, but must use as the man at the tub tempers and sends it to him through the pipes. In this way the size is kept in constant circulation within a few degrees of an even temperature, with the least possible chance for any variation of quality, and if any variation occurs, one man is entirely and alone responsible. Pails are not allowed in this slashing room; dippers we could not find, and a slack size warp is one of the things that are never heard of.

A new and original cotton house was hardly finished at the time of our visit. The building is 158 by 80 feet, six stories high, the stories eight feet from floor. The timbers are 13 by 14 inches, hard pine, planked with three inch tongued and grooved spruce; the actual clearance from the top of the floor to the under side of the beam is six feet and five inches. The intention is not piling the cotton or tiering it, but to stand it upon its end. In this way one man will handle about five times as many bales in storing as in the old way, tiering up or lying on its side. Each floor is intended to hold two thousand bales, leaving an alley-way either in the middle or upon one side four to five feet in width. When the alley is upon one side, a man takes the bale of cotton from the elevator upon a truck, wheels it wherever the lot with that mark and number is being packed, stands it up on end, and the job is done. The elevator is in one corner of the building, and extends from the basement to the top. The cotton is taken from the car, which stands at the door, thrown upon the man's truck, wheeled upon the scale and weighed without unloading, each truck being weighed. As soon as weighed it is sent to the elevator, where five or six bales are taken up at once. This makes in all a single unloading of it from the cars to the elevator, and from the elevator to its position on the floor or wherever it goes. If any particular lot of cotton is required, any especial staple, it will be seen the man goes down the alley until the proper mark or letter is found, takes out as many bales as is required, and in this way the mixing for the various numbers of yarn is made up in the cotton house. This building is as near fire-proof as can be, being built of brick with small windows (without any wood work), upon one end and one side. From the fifth story of the storehouse a bridge extends over the canal into the mixing room. The policy pursued here is of lifting the cotton in the raw state to the top of the mill, and as the various processes progress, from cotton to cloth, it is carried down hill all the way. For instance, what is now termed No. 7 was, at the time of our visit, being entirely refitted to contain in the upper story a mixing room, with several departments; into this mixing room, as we have already said, the cotton is wheeled from the storehouse.

As the mills are making a wide range of numbers, from 12 $\frac{1}{2}$  to 50, different processes and machinery are assigned to different numbers, each process requiring different selection and mixing of the staple. On the upper floor of No. 7 will be found piles of cotton for the different numbers. Through a trap door in front of each pile the cotton is thrown down in front of the opener lapper, where the machine receives the cotton from this bin or pile. Here the picker laps are made, and then are carried down into the next story by means of endless belts. The finisher lappers then do their work, and these laps in turn are sent down another story. Here they are put into a car, which carries the laps to the several mills without exposure to the atmosphere in any weather. Arriving at the door, they are put upon the elevator and carried to the highest story of the mill, where the breaker cards are located, then to the next story to the finisher cards and speeders, then down to the spinning, and finally down to the looms, which are upon the lower floors, from thence to the cloth rooms, the idea being that it is easier to carry a heavy weight down hill than up hill, and not only easier but saving in expense.

Mills Nos. 3 and 4 are now being extended, and are in quite a state of confusion. An addition, 60 by 78 feet, and six stories high, having been made, while between Nos. 4 and 5 a piece had been built in, fifty by forty-six, and six stories high, besides putting on a flat roof, four hundred and seventy-two by forty-five, the entire length of the mill. The cards were being moved on to the new floor at the time of our visit. The shafting was running on horses set up between the cards. The shafting at one end was running the cards on the old floor, and at the other end the men were setting up the shafting under the new roof and placing the cards in line. The old roof was only taken out part way, but the men were taking away the remainder. When finished this leaves the story below with more room between the floors, making a nice light card room under the new roof.

The mills have been undergoing a change from three to four years past, one of the main points of which has been the consolidation of the same kinds of machinery in the different departments. For instance, the frame spinning mule, the cards, slashers, and looms, so that each department will require only a single overseer, and the man in charge of the department can go from one to the other portion of his charge without going up or down stairs, or without having two or more sets of overseers. The carding will take the entire upper floors of Nos. 1, 2, 3, and 4, and one-half of the upper story of No. 6, mule spinning taking the entire floor around the entire concern, 1, 2, 3, 4, 5, and 6, about fifty-six thousand mule spindles upon the same floor or the same level, and the ring spinning running through an entire floor of 1,

2, 3, 4, and 5, the spooling, dressing, and drawing-in occupying the building over the boilers, engines, and coal house, and the warping occupying one story of the mill in No. 1 mill and connections. These floors of Nos. 1, 2, 3, 4, and 6, and three stories in No. 5, are occupied in weaving.

Over twenty kinds of goods are regularly made. Fancy goods, stripes, checks, fine muslin for bleaching, print goods and drills for export to China. The yarn made in this concern runs from No. 12 $\frac{1}{2}$  to No. 50, and goods from twenty-eight to forty inches wide are made. From one hundred and sixty to one hundred and sixty-five thousand pounds of cloth per week are turned out, using four hundred bales of cotton. Over fifteen hundred persons are employed, and forty thousand dollars per month paid for wages.

The cloth is woven a whole web or warp in a piece, and is taken to the cloth room in this shape. This is woven upon what is called the Boot loom. A peculiar system of accounts is kept in the cloth room, by which it is absolutely impossible for a weaver to take cloth to any extent from the mill. The cloth room and general storehouse are somewhat curious in the variety of grade, and in noticing the different destinations of the goods which are being sent out. The cotton is brought in the car in which it leaves Boston, New York, or any other point, unloaded, and the car pushed along a few feet, filled up with goods, and started on its way back.

To speak in detail of the concern would require very much more space than we can give, and perhaps be tiresome to the reader. It has been excellently managed, the goods are made cheaply, new machinery has been to a large extent put in place of the old, advantage has been taken of the dull times to do this, and now, as the change has come upon our manufacturing interests, these mills are certainly in condition to pay handsomely to their stockholders.

An extensive repair shop is one of the features of this concern, and not only repairs, but a very great amount of the new work for the extensions and modifications have been entirely done in it, in both wood and iron. In the recent experiments in small shafting and high speeds, Mr. Cumnock has made some practical applications which will no doubt be interesting to those of our readers who are among practical manufacturers. As one instance of this our attention was called to a steel shaft one and thirteen-sixteenth inches in diameter, running four hundred revolutions per minute, driving nine thousand Sawyer warp spindles, with all the preparation, including carding and speeders, to make the entire roving for nine thousand spindles, running on No. 23 yarn, seven thousand revolutions per minute, spinning one and one-third pounds on each spindle each week, running ten hours per day. All the pulleys upon the main line and upon the driving counters are thirty-six inches in diameter; the counter belts, widest are two and one-half, narrowest are seven-eighths of an inch in width; the pulley driving down upon the frame is thirty inches to fifteen inches, and a seven-eighths belt carries two hundred and forty spindles on a frame. This simply shows what speed will do in reducing the amount of iron or steel. The belting is reduced to the very minimum. In a recent test on the No. 6 mill, of the friction of the shafting and belts on the loose pulleys, the percentage of the whole power required was thirteen and one-tenth per cent. with the mill at speed, which is a very large reduction of the friction required according to recent figures in good mills, and the idea of a one and thirteen-sixteenth steel shafting doing what we saw this one, would hardly be believed. Yet it is a fact. The question of driving self-acting mules with pulleys, small shafting, long shafting, etc., has long been an open question. Mr. Cumnock has tried some experiments in this direction, and has in one place seven pairs of Platt mules, six hundred and forty-eight spindles, each mule running on a one and thirteen-sixteenth hammer iron shaft, made by the Nashua Iron and Steel Company of Nashua, N. H., with a balance wheel upon the end of the shaft weighing forty two pounds, thirty inches in diameter. He has no trouble whatever with it.

Arrangements have just been made to add the Garland atomizer or moistening apparatus to these mills, in different departments. The alleys which are most used are all laid with rock maple. This has been in use for ten years with hardly an impression of wear made upon it.

The mills are under the management of Alexander G. Cumnock, who has been in charge some twelve years, and to whom we are indebted for the information gathered in a half day's look over this concern, which we certainly enjoyed, and to which we hope, at some future time, to again refer, as well as to other matters which are now in progress. The main point of this article has been to show the advantages and improvements which have been introduced by Mr. Cumnock, increasing the production, making better goods, consolidating his different departments, and especially with the admirable arrangements for controlling the power, all of which are of interest to every manufacturer. We believe, by such comparisons, improvements will be made upon all sides.

Some further data was given us regarding some tests made by James B. Francis, C.E., of Lowell, of which we shall at another time make an article, and should our readers wish to see a concern which is well managed, and improve their knowledge somewhat of modern economy in cotton spinning, we certainly don't know of a better place to go than the Boot Cotton Mills, Lowell.

#### THE BLEACHING OF JUTE YARN.

JUTE being used nowadays in such various ways for textile fabrics, it becomes of importance to know in how far it can be bleached. Repeated trials to treat it in this respect like flax or hemp yarn have shown that though it can, like these, be bleached a perfect white, the color soon loses this purity and assumes a yellowish tinge; moreover, the yarn after a while gets decidedly weaker. Thus bleaching to a pure white had to be abandoned for the safer cream color. Jute cannot stand boiling in soda, which turns its color into a reddish brown; diluted acids injure it still more; only chloride of lime can be used if applied with care.

To bleach the yarn it is brought in hanks and hanging upon rods in a weak and slightly warmed solution of chloride of lime, in which it is turned from 30 to 50 minutes. If the hanks are only partly submerged, and thus come alternately in contact with the atmospheric air, the process of bleaching is quicker, but there is danger of injuring the yarn; it is therefore safer to entirely submerge it, though by doing so it may take more time; the only drawback is the necessity for special apparatus. There are several kiers required, which can be heated; the rods to hold the yarn must be made of a substance which is not injured by the chlorine, and they must be mechanically turned during immersion; there must also be a contrivance to transfer the yarn quickly from one kier to the next. The jute yarn by this process receives first a weak tepid soap bath for about

ten minutes; after allowing it to drip off, the yarn is then put for forty minutes into a solution of 1-0035 specific gravity of chloride of lime, then passes again through soap and water, and again chloride of lime, and so on until the required shade is obtained. Lastly, it is washed in tepid and then in cold water, wrung, and dried in the air.

#### SHALL WE HAVE A CANAL OR RAILWAY?

In commenting upon the project of Count de Lesseps, I shall consider the subject simply as an engineering one, and in relation to its practicability, its probable cost, the time needed for its completion, and its utility when completed.

The question of the practicability of opening a tide level waterway through the American isthmus is simply a question of money and of time. If sufficient money were supplied, and time enough were given, I have no doubt that, instead of the narrow and tortuous stream which Count de Lesseps proposes to locate at the bottom of an artificial cañon to be cut through the Cordilleras at Panama, engineers could give to commerce a magnificent strait, through whose broad and deep channel the tides of the Pacific would be felt on the shore of the Caribbean Sea, and through which the commerce of the next century might pass unvexed from ocean to ocean.

The science of engineering teaches those who practice it how the forces of nature may be utilized for the benefit of mankind, and it is the duty of an engineer when charged with the responsibility of solving an important engineering problem by which his fellow men are to be benefited, to consider carefully how the desired results can be most cheaply and most quickly secured. Therefore, it is his duty to consider every method for the accomplishment of the end in view which science and nature have placed within his power, and to select from the fullness of their stores such methods as the precise teachings of mathematics and a knowledge of the laws which control the forces of nature assure him will certainly accomplish the desired result in the least time and for the least money.

Where the growing demands of commerce at the crossing of a river are no longer met by the use of a ferry, the engineer suggests a bridge; and to prevent injury to the commerce of the river and save the cost of an excessive height in the structure, he plans in its roadway a draw that may be opened for the traffic of the river and closed for the traffic of the land. If the traffic of either be too great to admit of interruption, he is then justified in erecting a higher and more costly structure, which shall let the commerce beneath it pursue its path uninterrupted, while that which demands a transverse route will pass over a permanent highway. But his profession in such case likewise suggests another alternative. It is possible to bore through the earth beneath the river, and thus open an unobstructed path by other means for the transverse commerce which has grown too great for the ferry. Before recommending the costly bridge, it is his duty to investigate the merits of the tunnel also; and if he find that to be the cheaper and the quicker remedy, he should lay the two plans with all their advantages, with his advice in the premises, clearly before those who are to pay for the work.

When the commerce between the east and west shores of the Atlantic grew so great and impatient in its demands that the winds of heaven no longer sufficed to hurry it on, the world was startled with the proposition to harness another one of nature's forces to the car of commerce, and the expansive property of steam was thereupon immediately applied in the propulsion of ocean ships. Men, whose thoughts had been confined to one channel alone, shook their heads in doubt, although for many years before they had seen the same force applied to vessels engaged in river navigation. When the Thames tunnel was proposed, where the river traffic at the locality interdicted the erection of a bridge, the same class of men again shook their heads, because to them the antiquated ferry-boat was the sole solution of the problem. They knew it was as old as the canals of the Pharaohs, and their prejudices in favor of old methods led them to look with doubt upon this plan of crossing a river; but now, tunnels under rivers are recognized as one of the approved methods of engineering.

Large, fertile, and valuable tracts of land have been reclaimed by cutting canals, in which the superincumbent water could flow off to lower levels; but when engineers proposed to reclaim the land which was once covered by the lake of Haarlem, by a reversal of this method, and, by the use of steam, proposed to lift up the water of the lake into canals many feet above its bed, the doubters again shook their heads; but it is now proposed to apply the same successful method to reclaim the enormous area covered by the Zuyder Zee.

The ancient bridge builders excluded the water from their shallow foundations and began to build the piers for their bridges at the bottom of the river; but the commerce of late years has demanded bridges where it was necessary to sink the piers in much profounder depths, and the engineers of the present age have reversed the old methods, and begin the building of the piers of their bridges now on the surface of the river, and sink single masses of masonry weighing forty thousand tons through immense strata of alluvial deposits, down to the bed rock at great depths below, by scientific methods totally unknown to the ancients.

It should be borne in mind by laymen that the science of engineering is based upon natural laws that are absolutely unalterable—laws that are therefore absolutely reliable; and that through the control which scientific discovery has given to the engineer over the forces of nature, the only limit to the possibilities of his profession lies almost wholly in the cost of the works which he proposes to execute. For this reason, the limit which should control the magnitude of his projects should not exceed the real necessities and the financial abilities of his fellow men. But should there occur a pressing need for a tower so high that it shall penetrate the regions of eternal snow; or an arch so vast that its span may be measured by the mile; or a tunnel through the broadest base of the Rocky Mountains; or a railway that shall transport, entire and uninjured, the grandest of the Egyptian pyramids; or a channel through Darien big enough to disturb the flow of the gulf stream and alter the pulsation of the tides; you may be assured that each and all of these things, and many more, are within the possibilities of his profession, if you will only furnish the money to pay for them. Hence any intelligent engineer, having a just conception of the immense capabilities of his art, will at once concede that it is entirely possible to cut the little passage through the Isthmus of Panama, twenty-eight feet below the ocean level, as proposed by M. de Lesseps, provided the money be supplied to meet the cost. But if an engineer be asked to

\* Remarks of Mr. Rada made before the House Committee on Inter-oceanic Canal in answer to Count de Lesseps, March 9, 1880.

estimate accurately the cost of such a cut, he will tell you that there is one important element of expense in the plan which it is impossible to ascertain with any degree of accuracy. He will tell you that so long as the bottom of the canal is kept above the ocean level, the average rainfall at Panama will enable him to estimate with some degree of certainty the probable quantity of drainage water that must be taken care of to enable the work to progress uninterruptedly. But when the ocean itself is tapped, as it must be in cutting the canal twenty-eight feet below its surface, natural methods of drainage become impossible, and the quantity of water which will probably enter through reefs and fissures below the ocean level, in the uplifted and disturbed stratification of the Cordilleras, through which the canal is to be cut, is an unknown quantity, which engineering science cannot determine in advance.

Assume, however, that the engineering difficulties involved in the drainage of the works during construction; and those inseparable from the construction of a canal through the sickly bottom lands of the Chagres River; the damming off of its frightful floods; the creation of a new bed for its waters; and the deepening of the old one to constitute a part of the canal, can all be overcome by engineering skill, the question of expense still remains open and undecided; nor can it be fairly answered until the work has been completed. The cost of any work must always depend upon the number and character of the difficulties to be met and overcome, and the difficulties involved in the construction of a tide level canal (only some of which I have mentioned) are of such a character that it is utterly impossible to fix with any degree of certainty the aggregate cost of the work. True, an estimate may be made, as indeed it has been, by the engineers employed by M. de Lesseps. They have agreed upon the sum of \$168,000,000 as the ultimate cost of the work, exclusive of interest during construction, but experience has shown that such estimates are quite unreliable, and are always much below the actual cost. I believe that the estimates for the construction of the Suez Canal were \$40,000,000, while its actual cost was upwards of \$90,000,000. It is not unlikely that upon the completion of the Panama Canal, it would be found that the money expended was, in amount, twice as much as that estimated.

Another important question to consider in connection with this matter of expense is that involved in the maintenance of the work after it shall have been completed. Any one who contemplates the proposed depth of the cut through the several miles of the Cordilleras, and thinks of the frightful rains and tempests which prevail during six months of the year, can form some faint conception, perhaps, of the amount of material which would be washed down the sides

satisfied himself that the results sought to be attained could not be as well secured in a less costly way.

When the St. Louis Bridge was to be built, every system of bridge construction was examined to ascertain the cheapest method of building it, and various modifications of the plans were tried for the purpose of lessening its cost. A tunnel under the river was likewise considered. The result of all these studies was the erection of the present structure. The bridge proper, including the stone arches on each bank of the river, but exclusive of the tunnel and approaches, cost almost exactly \$5,000,000, which was about twenty per cent. more than the estimate for it. The actual cost, however, was more than doubled by the items of interest, commission, discount, legal expenses, etc., which had to be paid. These items were omitted by M. de Lesseps, and formed no part of the estimate of the cost of his canal which he gave to the committee yesterday; and, although they cannot be properly said to be items of engineering, or even such as can be controlled by engineers, yet the fact is that they are inseparable from all great works. In the case of the St. Louis Bridge the three first of these items alone cost the company \$5,000,000, or as much as the entire cost of the bridge itself.

It would be the duty of an engineer if charged with the solution of this Isthmian problem, if untrammelled by instructions from his employers, to investigate every method by which this barrier to commerce can be overcome. Unfortunately, every expedition which has been sent out by this or any other government, or individual, so far as I have knowledge, looking to the transit of ships from ocean to ocean, has been instructed to find a practical route for a canal, and a canal only. Yet no intelligent engineer, who will divest his mind of all prejudice and take up the question of transporting ships over the Isthmus by railway, can fail to be convinced:

- 1st. That this method is entirely practicable.
- 2d. That upon any route where it is possible to build a canal, it is equally possible to build and equip a substantial and durable ship railway for one-half the cost of a canal, if it be built with locks, and for one-quarter of its cost, if it be at tide level.
- 3d. That such a ship railway can be built in one-third or in one-quarter of the time needed for the construction of the canal.
- 4th. That when built, ships of maximum tonnage can be moved with safety at four or four times greater speed on the railway than in the canal.
- 5th. That a greater number of vessels per day can be transported on the railway than would be possible through the canal.

FIG. 1.

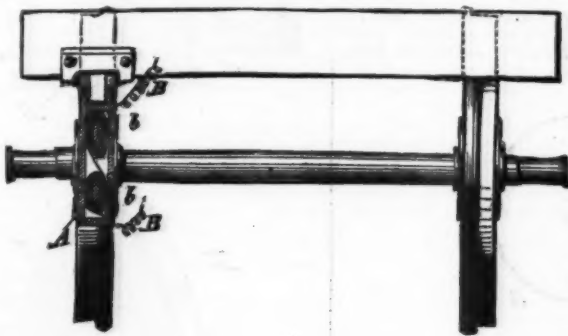
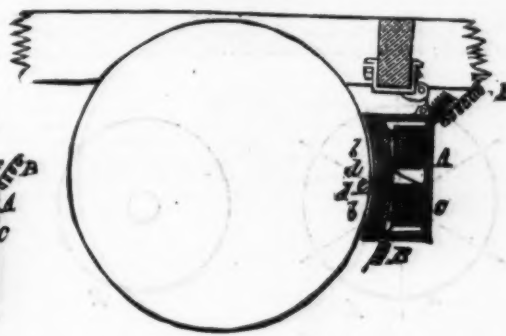


FIG. 2.



### ELECTRIC RAILWAY BRAKE.

of this immense cut, as well as from all the other parts of the canal, and which must be continually dredged out of it, to preserve its usefulness.

The great delta at the lower end of the Chagres River is formed by the alluvions contributed from the high lands. These have been washed down from them into the river, which by its current has borne them out to the sea, where they have formed an immense deposit many miles in extent. Similar deposits must form in the canal from the same cause, but as it will be without sufficient current to sweep them out to sea, they must be removed at great cost by artificial means. Experience in the maintenance of works constructed through districts visited by heavy rains proves that such maintenance is always attended with very large expenditures.

Should the canal ever be completed, with a cross section as small as that proposed, and which cannot be increased except at enormous cost, and a stoppage of its traffic during enlargement, it will not be practicable for large ships to move in it at a higher speed than two or two and a half miles per hour. Ships moving through narrow channels in a depth of water only a foot or two in excess of their draught are liable to take what pilots call "a sheer," or suddenly change their direction, and leave the shore which they are nearest to, and bring up against the opposite one before they can be controlled. In a narrow channel way, if the vessel be moving nearer to one bank than to the other, the water which flows from the stem of the ship to the side nearest the shore causes an elevation of the surface of the water on that side of the bow greater than the surface of the water on the other bow. The keel being too close to the bottom to prevent an easy flow under it, and the water between the bow and the nearest shore being higher than that on the other side, the bow of the ship is forced away from that shore and brings up against the opposite bank. The more rapidly the ship is moving the more likely is she to take "a sheer," and the more violent will be the contact with the bank. The day before my recent visit to the Suez Canal, a ship had been detained in it twenty-four hours, by getting aground in this way. It can be readily perceived that if the canal were cut through rock, such an accident would involve injury to the vessel. Through the alluvial portion of the canal a low rate of speed would also be indispensable to prevent the injurious effect of the wash of the waves made by the ship.

While I have always been an advocate of those great public improvements which are necessary to meet the wants of commerce, I have constantly maintained that these great enterprises should be completed by the most economical methods known, and I think that an engineer would not be justified in advising the prosecution of a work involving very large expenditures of money, until he had

6th. That the capacity of the ship railway can be easily increased to meet the demands of commerce, without interruption to its business, whether it be to meet an increase in the size of the ships or in the number of them.

7th. That the cost of maintenance of the roadway and rolling stock will be much less than that of the maintenance of the canal.

8th. That the cost of maintaining and operating the railway, taken together, will be less than that of operating and maintaining the canal.

9th. That the railway can be located and successfully operated at localities where it is not practicable to construct a canal.

10th. That it is possible to estimate with great accuracy the cost of a ship railway, and the time needed to build it, because the work would be almost wholly upon the surface of the ground, whereas the canal is strictly a hydraulic construction, involving control of water and the execution of works under water, or liable to be submerged or interrupted by water, thus rendering anything like an accurate estimate of the time and cost of its construction an impossibility. Hence capitalists cannot know with certainty the amount of money and time required, or what profit the canal will probably pay, when finally finished.

I am ready to establish the correctness of these propositions before the committee; and to answer any objections to them which may be urged by experts or others at any time.

My own studies have satisfied me that the largest loaded ships may be carried with perfect safety at ten or twelve miles per hour on steel rails weighing but seventy pounds per yard, the kind used on first-class railroads, and on wheels which shall not impose as great a pressure upon the rails as that of the driving wheels of a first-class locomotive when at rest, and that no grades need be encountered from ocean to ocean on several routes greater than one per cent., or 53 feet to the mile.

The application of the railway system to the transportation of ocean vessels promises more certainty of success than was given in favor of the application of steam on the ocean before the passage of the Great Western from Liverpool to New York. The present proposition is not so much of an untried experiment as that was, because to-day vessels of a few hundred tons burden are being transported by railroad both in this country and in Europe. Forty years ago large canal boats were, and I believe are yet, transported over the Alleghenies in Pennsylvania on the Portage Railway, and surely with the wonderful achievements of the past forty years before us, no intelligent man will doubt that we can transport ships to-day by railway as easily as we could transport canal boats forty years ago by the same method.

Six years ago, when the question of opening the mouth of

the Mississippi was being considered, the only means supposed by the great mass of the public to be possible was a canal, as in the present instance. It then required the utmost efforts and most persistent arguments to induce the government to try the cheaper and quicker method of solving the difficulty by jetties. And so strong are prejudices fixed in the minds of men that it is not at all unlikely that if the jetty plan had not been backed up by my proposition to assume all the financial, and, I may add, the professional, risk of failure, with the offer to do the work at less than the official estimates of its cost, the government would to-day, and probably for ten years to come, be delving in the swamps of Louisiana to construct a canal at a cost of three or four times greater than the jetties which to-day maintain the deepest and safest entrance into any harbor from Maine to Mexico. Now that the cheaper and quicker plan has been tried and found to be a success, it would no more be exchanged by the public for a canal than they would exchange the magnificent ocean steamers of to-day for the clipper ships of the past. If their huge sails were seen alongside of the smoke-pipes of a White Star, a Cunard, or an Inman steamer, they would appear as absurd as the Fort St. Philip Canal scheme does when compared with the jetties of to-day. Is it not probable that the Isthmian canal schemes, which are now absorbing so much of the time of the honorable committee, will appear equally absurd after the completion of a ship railway?

In conclusion, I beg to suggest that it is of the utmost importance to American commerce that it shall be enabled, when works upon the Isthmus are built, to receive all benefits and advantages therefrom at the least possible expense. It must be conceded that the capitalists, who will control the works when built, will be entitled to realize a profit proportioned to the magnitude of their investment, therefore it is a question of the first moment to the American people whether the necessary means cost \$250,000,000 or only one-quarter of that amount.

### ELECTRIC RAILWAY BRAKE.

ONE of the most recent forms of continuous brakes is that invented by Mr. A. C. Boothby, C. E., of Kirkaldy, N. B., in which apparatus the operation of the brake-blocks for retarding or arresting the motion of a train is effected by means of electricity. For this purpose an electric current is applied directly to the brake-blocks when the latter are of iron or steel, or to the shoes which carry the blocks, when wooden brake-blocks are used; the blocks or shoes, suspended in proximity to the revolving wheels, being converted into powerful electro-magnets when the brakes are to

be applied, are attracted to and press upon the treads of the wheels with a retarding force proportioned to the strength of the current employed.

For the purpose of operating either the whole or any desired number of brake-blocks, conducting wires are led throughout the train, and are connected at their ends so as to complete the circuit.

The electric machine employed for generating the required current is by preference driven independently of the driving-power of the train.

Fig. 1 represents respectively an end elevation, and Fig. 2, a side elevation of a portion of the lower part of a railway carriage or truck to which Mr. Boothby's apparatus is applied.

In these figures, the brake-block is marked A, and the wires for conveying the electric current from the generator are shown at B, B, these wires being continued in coils wound round soft iron cores, b, b, which are connected at the back by a soft iron backing, c. The surfaces, d, of the blocks which bear on the tread of the wheels are fixed to the cores, b, b, with a filling-piece, e, of gun-metal between them.

Whenever an electric current is sent through the wires, B, B, the coils round the cores, b, b, the brake-blocks are converted into electro-magnets of sufficient power to be attracted to and bear upon the tread of the wheels with the force necessary for retarding the motion of the latter.

The machine which generates the electricity may be a Gramme or Siemens machine, or other dynamo-electric machine capable of giving the necessary strength of current; it is placed on the locomotive, and worked by a small special engine supplied by steam from the boiler of the locomotive, the supply of steam being effected by opening a valve upon a steam-pipe communicating with the special engine.

The carriage, engine, and brake-van are provided with communications with the steam-valve, by means of which it may be opened when it is required to apply the brakes. These connections may consist of a chain or rope extended throughout the train, and connected to a lever upon the valve. This rope or chain is so situated that it may be readily pulled by the guards, or by the passengers, independently of the engine driver, by means of rods connected with the rope and terminating in handles in or on the carriages and brake-van, so that by pulling any rod the valve may be opened, and the electric machine set in action so as to work the brakes.

The chain also causes the operation of the engine driving the electric machine, and thus applies the brakes, in the event of a portion of the train breaking away; this is effected by the valve opening by reason of the tension upon it.

The conducting wires are formed into coils at the ends of each carriage, so that in the event of a break-away of any

portion of the train, the wire becomes uncoiled sufficiently to prevent immediate fracture of the wires.

For the purpose of insuring at all times and at any part of the train the making of the circuit, in the event of a part of the train breaking away, the positive and negative wires in each carriage are connected together by a platinum wire, or other substance offering great electrical resistance. When the train is in its normal condition, the platinum wires, or their equivalents, by virtue of their high resisting power, prevent the passage through them of any considerable quantity of electricity, but in the event of the normal completion of the circuit being destroyed, the platinum wires for a time make the circuit complete. Instead of the means above described, dipping-bars in connection with mercury cups, or other mechanical devices, may be employed for completing the circuit, in case of a separation of any portion of the train.

The brakes on the guard's van or on the engine and tender may be fitted with the ordinary hand appliances, either independently, or in combination with the electrical apparatus for applying the brakes.

The brake-blocks are faced with a bearing-face, which can be readily removed and replaced when worn. In Fig. 8 is shown a slightly modified form of brake, the parts corresponding with those represented in Figs. 1 and 2. In this example, the cores, *b*, and the wires, *B*, are protected by a leather covering, *f*, thus obviating the cost of metal covering, as shown in the other figures.

#### BALANCING PULLEYS AND OTHER ROTATING PARTS OF MACHINERY.

By ITHURIEL.

ALLUSIONS have been made by writers in mechanical journals to a machine, made "somewhere out West," for the production of a "running balance."

We will describe the apparatus and present the deductions of experiments, which have been deeply interesting to all who have witnessed them.

The following Report of Committee on Science and the Arts, of Franklin Institute of Philadelphia, January 15, 1878, furnishes a succinct general description:

REPORT OF COMMITTEE ON SCIENCE AND THE ARTS.

No. 1107.

HALL OF THE FRANKLIN INSTITUTE,  
PHILADELPHIA, January 15, 1878.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination the device for balancing flywheels, pulleys, and the like, the invention of Mr. C. Seymour, report that the apparatus consists of a hollow conical base, in the center of which is placed a vertical spindle standing in a step-bearing in the base of a cone and passing a short distance above through a bearing at the apex of the cone. This spindle carries near its upper end above the cone a horizontal, vertically adjustable driver, or

anced, and to keep the clutches apart when it is desired to examine, test, and mark the object while running alone. As the driving pins are liable, when pressing against the arms of the object to be balanced, to produce uneven rotation, the true unbalanced condition is best shown when the rotation is continued by the momentum acquired after the driving gear is released by the parting of the clutch.

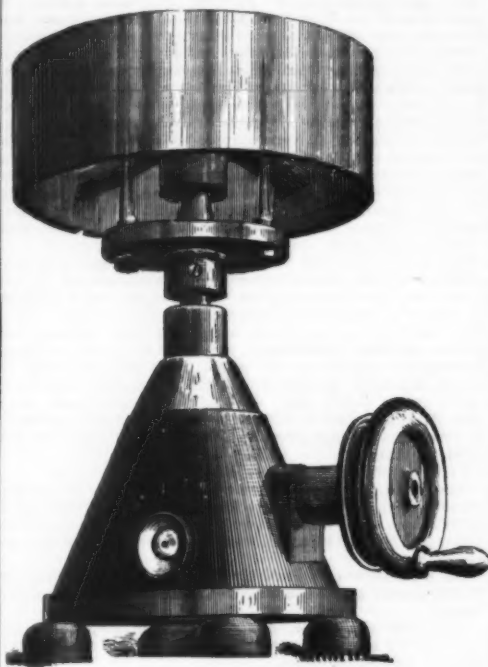
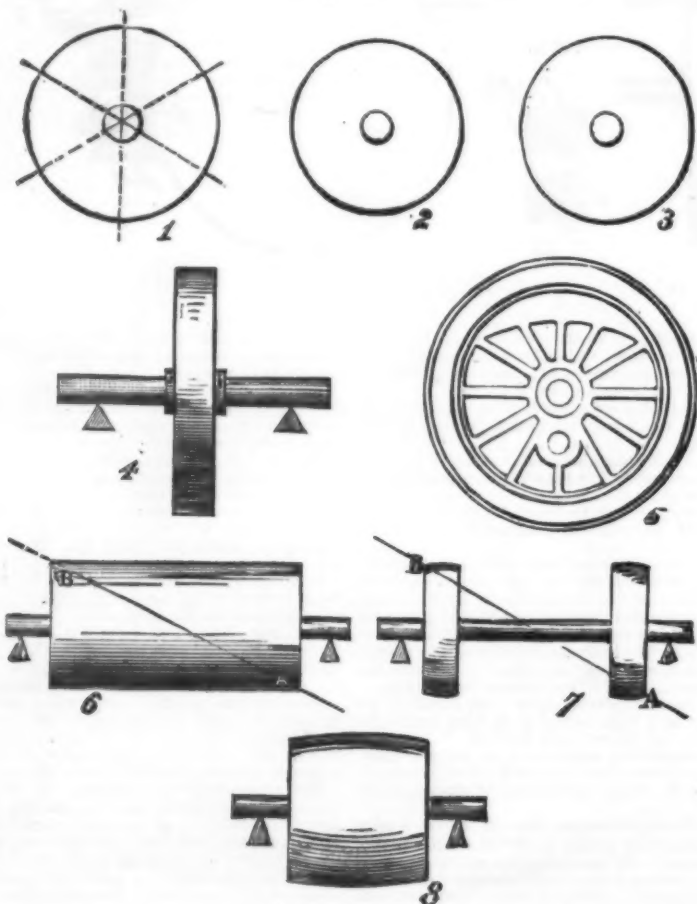


FIG. 9.

Practice has shown that the point of support during rotation should be near the center of the mass.

To balance any object, secure first the proper plug in the hub of the object to be balanced in such position that the point of support on the vertical shaft will be slightly above the center of gravity of the object, then rotate the same,



yoke, provided with two carrying pins projecting upward parallel to axis of the spindle. The upper end of the spindle is reduced to a conical point, and upon this rests the object to be balanced, each being provided with a plug, snugly fitting in and secured to the bored holes of the hub, and having a central conical cavity of larger angle than the point of the spindle upon which it rests.

The vertical spindle is rotated by friction gear driven by a horizontal shaft in a bearing in the base, provided with belt pulleys on its outer projecting end.

The base is firmly fixed to floor or foundation, independently of the driving pulley stand, for insuring steadiness of motion. This horizontal driving shaft is in two parts, connected by a face-plate friction clutch, and moved longitudinally by a counter-weighted lever, so arranged that the weight may be used to press the clutches together when it is desired to rotate the object to be bal-

observing and marking the part which "runs out," and finally fixing the balance by the application of plastic material in the usual way for balancing with mandrel and straight edge.

For pulleys to be run at low rates of speed, it is found sufficient to apply but one balancing weight, but when very high velocities are to be attained, this machine is well adapted for determining all the conditions necessary to perfect rotating balance, even at very high velocities.

Experience proves that, for balancing pulleys whose face is somewhat greater than their diameter, this machine is even better adapted than for pulleys of the usual proportions, and it is also proven by the aid of this machine more objects can be balanced in a given time than by the usual methods.

The committee examined thoroughly a full-size machine at the "Industrial Works," in this city, set up for use and

obtained from an expert skilled in practical mechanics and the use of this machine, the results of his experience.

The committee highly recommend this machine to all parties who have balancing to do, and, provided the machine can be bought at a fair price, it must take preference over all others.

The above report was approved March 6, 1878, with the recommendation of the award of the Scott Legacy Premium and Medal.

A true copy.

J. B. KNIGHT, Secretary.

A brief allusion to the old method of balancing by straight edges, with its burden of fallacies, is all that is needed to show its inadequacy. Thin disks or wheels, like Figs. 1, 2, 3, and 4, whether symmetrical or not, may be brought approximately to a balanced condition by means of the straight-edge test, but it is a tantalizing approximation, and leaves us utterly helpless with high speeds; while, in testing objects like Figs. 6 and 8, the straight edges are not only useless, but are as likely to contribute to error as to truth. Chordal illustrates, graphically, the possibilities of their doing more harm than good, by supposing that a drum may possess the properties of two pulleys upon the same shaft, as represented by Fig. 7. He says: "If you have a shaft six feet long, with a perfectly balanced pulley on one end and an unbalanced pulley on the other end, and put it on the usual straight edges, you will find weight to be needed somewhere. You can put it on one side of the good pulley and get your job to look perfect. It will stand still, and stop still, and start easy, but you know quite well that the pulleys are not as much balanced as before, for you have destroyed the balance of the good pulley and have not touched the bad one."

Figs. 9 and 10 represent a small experimental model, but which is large enough to balance objects weighing twenty pounds. A is the case of a machine resting upon rubber feet; B, spindle of steel; C, frictional gear; F, plug in the hole of pulley; A' and B', balance weights in the rim of pulley.

Fig. 11 represents a large machine, suitable for balancing objects that weigh ten pounds or a thousand pounds. It is driven through the media of frictional gearing, frictional

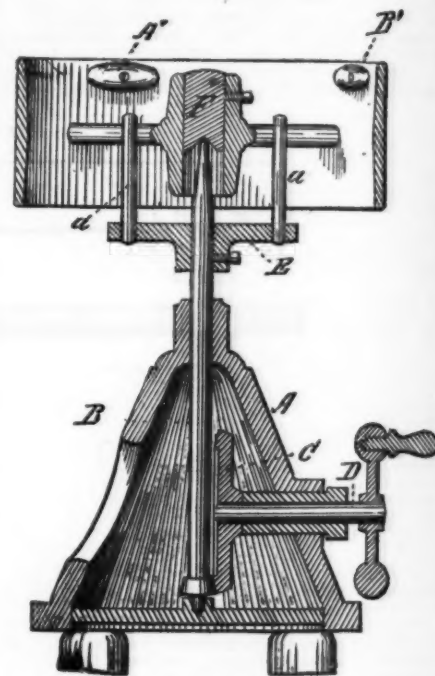


FIG. 10.

clutch, double counters, and tight and loose pulleys, so that when the object to be balanced has attained the desired speed, the disturbing influences of the motive power may be withdrawn.

In describing the method of balancing a pulley, we will leave the reader to infer the reasons for the various operations, believing them to be sufficiently obvious. We place the pulley on the pivot of the spindle, B, Fig. 10, and, before rotating, locate near the center of the rim a weight of about the size necessary to produce a standing balance; then rotate and mark upon the edge of the rim with chalk. If the mark occur within one-fourth of the circumference of the pulley from the weight, raise the weight, and at the same time advance it toward the mark. If the mark occur at more than one-fourth of the circumference from the weight, depress the weight, and at the same time retreat from the mark. If, by these steps, the edge of the rim is reached by the weight, and the pulley still runs out, increase the weight, and place a counter-weight diametrically and transversely opposite, so that the relative positions of the two weights will be as are those of B and A, in Figs. 6 and 7. Care must be taken at every adjustment of weights that a standing balance be not violated. If, upon the readjustment of the first weight, the mark occur at one-fourth of the circumference of the pulley from the weight, nothing more can be done with such weight, but an additional weight must be placed at the mark, and if this second weight disturb the standing balance, locate a counter-weight, as in the first described condition.

In balancing objects in which the center of magnitude is inaccessible by the pivot of the balancing machine, such as, for instance, a planer cylinder or a thrashing machine cylinder, an entirely different method is necessary. A planer cylinder will sufficiently illustrate all cases. Let it be suspended in gimbals, as shown in Fig. 12, and driven by frictional contact with the face plate of the pulley balancer or by other convenient means. A small portion of its length should project above the gimbal pivots, O, C. Bring the frictional gear, H, in contact with the face plate by a steady bearing of the hand on the cross-head, I, until a sufficient speed of the cylinder is attained to throw its maximum amount; then bear it slowly away from the face plate, and

mark with a pencil of moistened clay or chalk upon the lower journal or other concentric part. The mark will always be found on the light side. The correction, either by cutting away the opposite side or counter-weighting the light side, should be made at a distance from the lower end not exceeding half the length of the cylinder. When the lower end is thus corrected the cylinder is reversed, and the other end treated in like manner.

These methods of balancing the revolving parts of machinery have been in actual practice for several years, and have never yet failed. The apparatus and operations involve much expense, patience, time, and skill, requiring a careful and substantial setting of the machine, removed from jars, wind currents, Cheap Johns, and fools. No man who is unwilling to throw away his straight edges and work conscientiously should ever ask questions about the methods, for he would condemn them as requiring too much time

ing, without rotating upon its mechanical center. In other words, its mechanical center will coincide with its center of gravity.

**Maxim D.**—If there be within all parts of a circle described by the center of gyration of a rotating body a sufficient amount of matter to resist by reaction the centrifugal tendency of an excessively heavy portion, such heavy portion will strive to recede from the mechanical center so long as the impelling force applied at the center continues and is opposed by inertia. But when the inertia is overcome, the heavy portion will strive to approach the mechanical center.

**Maxim E.**—If the axial diameter of a rotating body exceed its equatorial diameter and its plane of rotation be disturbed, it cannot recover its equilibrium within the first plane, but will strive to rotate in a new plane parallel to its greatest sectional weight.

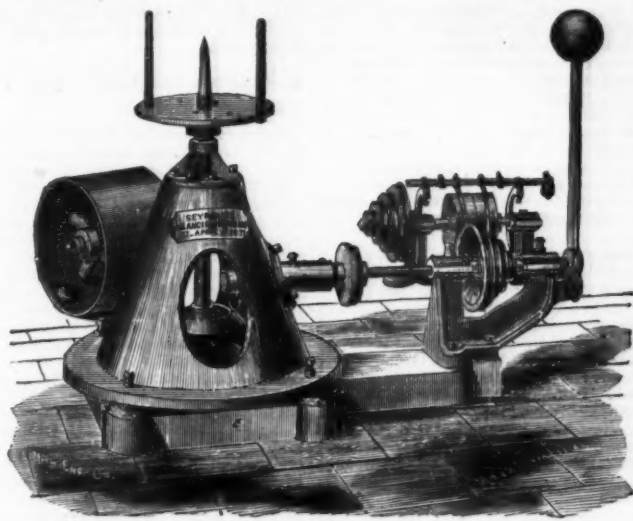


FIG. 11.

and pains. His will be a "standing balance" in more than one sense.

I have absorbed this much of your valuable space, and have not yet rendered a reason for anything. I have tried to avoid it. We are too prone to advance reasons for what we do, and fancy that we are reasoning, when we are only theorizing. Next week I will give you the deductions of extended experiments, and I will endeavor to deal with nothing but facts until the field widens to where hypothesis is too tempting to be resisted. The field is large, and as yet there is hardly a foot-print in it, nor will there be until the scientist and the artisan meet upon common ground. The physicist, astronomer, and engineer must compare notes and compute the value of analogies. All things either rotate or revolve, or are influenced by attracting bodies. And yet, from the immeasurable suns to the boy's play-hoop, we are ignorant of their character, and really know but little of their conduct.

CHARLES SEYMOUR.

DELIANCE, O., Nov. 18, 1879.

In the course of the experiments, the results of which I promised last week to present, some conclusions were reached, which seemed sufficiently stable to be regarded as laws. For the convenience of reference and for conciseness, we may arrange them as such.

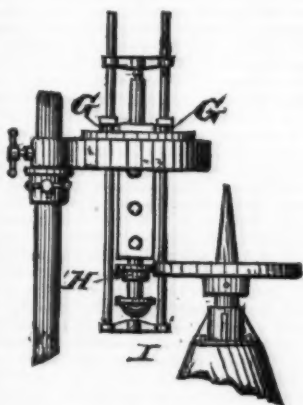


FIG. 13.

If it be desired that a rotating body run smoothly without jarring its surroundings, its condition must be the same as those of a body rotating in space, having a mechanical center, upon which it is desired it should rotate, and a mechanical plane, upon which it is desired it should continue.

**Maxim A.**—Its mechanical center must coincide with its center of gravity, or it will leave its mechanical center, upon which it may be supposed to have been set in rotation, and assume a center nearer to the super-abundant weight by which its equilibrium is destroyed.

**Maxim B.**—Every rotating body must be considered as having an axial dimension, or line, measurable in a direction transversely to its plane of rotation. In order that it may rotate in a certain mechanical plane relatively to its form, there must be an equal distribution of weight in directions parallel to the plane of rotation about every point in its axial line. The center of percussion of a rotating body is that point at which it can oppose resistance or strike an obstacle without communicating a shock to its axis. It coincides with the center of gyration.

**Maxim C.**—If a rotating body have a corresponding distribution of matter about all points in a circle described by its center of gyration, it will be in equilibrium, when rest-

If some of the above "maxims" seem too obvious to require so formal a position as that which they occupy, it is owing to a desire to comprehend all the conditions and qualities of the rotating bodies with which mechanics have to deal. Mechanics, and even teachers of the laws of physics, have too commonly drifted into conclusions by a loose habit of thought, and entertain impressions which are indications of an entire absence of observation. They are very persistent in holding to these conclusions and impressions. A scientific (?) journal, in treating of wheels on shafts, states "that an unbalanced rotating disk will tend to bend or spring the shaft toward the heavy side." And, again, swelling with the inspirations of mathematical formulae: "An over-weight of  $W$  lb., describing a circle of radius,  $r$ , with a velocity of  $v$  feet per second, will bring a strain upon the

comparisons of the amount of statical depression with that of dynamical depression, and, while intent upon the main object, thoughtlessly made an erroneous statement. The statement was merely incidental, and, therefore, does not invite severe criticism; still, it is to be regretted that his master mind was not detained longer upon the cause of the dynamical depression, for he certainly would have measured its full import and have avoided the marring of a page.

The vibrations or jarring caused by the unbalanced rotating parts of machinery are owing, not to centrifugal force, but to a striving, as of all rotating bodies, to assume rotations upon their centers of gravity. The amount of "throw" is generally very small, notwithstanding the violence of its energy. There are stationary parts in the construction of nearly every machine, which are capable of vibrating in unison with the times of rotation of some running unbalanced part, and which are also capable of serving as accumulators of vibrations. Accumulations thus arising may be, mathematically, the multiples of the times of the vibrations of other and heavier parts; and it is obvious that a violent shaking may ensue, even when the initial vibration is so small as to be almost inappreciable. The aggregation thus subjected to vibration will have a natural, isochronous movement, the periods of which will depend on its inertia, distance from its natural center of motion, and the restraints imposed by rigidity of fastenings upon its tendency to oscillate upon such center. When the periods of semi-rotation and the periods of natural vibration coincide, a continuous, but not always uniform, oscillation, will be established. Upon the establishment of such oscillation the time of rotation will become slower and the time of oscillation faster. That portion of the rotating body which possesses the excess of weight will, during its semi-rotation, strive to move in directions opposite to those of the vibrating mass, and, if it were not for the time which necessarily elapses in the transmission of force from the rotating body to the vibrating mass, the movements would be diametrically opposite. The conditions, depending on dimensions, weights, times, and structure, are so varied and complex that the relative times of the movements can only be determined by experiment in each individual case. Upon this latter portion of the subject we will soon have more matter, which we will be pleased to submit to you.

Fig. 13 represents the entire apparatus necessary for balancing all the rotating parts of machinery:  $J$  is the principal machine or "pulley balancer;"  $K$  is attachment, with gimbals, for balancing planer cylinders and such other objects as have to be rotated upon centers;  $L$  is a small machine for balancing small objects;  $M$ , a proportional scale for balancing planer knives, moulding bits, screws, etc.;  $N$  is a rest and gauge, with receptacles, for marking materials.

It is hoped this subject of balancing and the qualities of rotating bodies may excite inquiry and discussion among your able contributors, and thus enlighten a field of pleasing investigation.

DELIANCE, O., Nov. 27, 1879

#### ROLLING PLATES.

At a recent session of the Institution of Mechanical Engineers, Mr. Hutchinson read a paper on "Improvements in Machinery for Rolling Iron and Steel Plates." Of this we give an abstract.

Before describing the improvements, the author briefly notices the method generally adopted at present in rolling plates, as compared with that in use for producing flat bars,

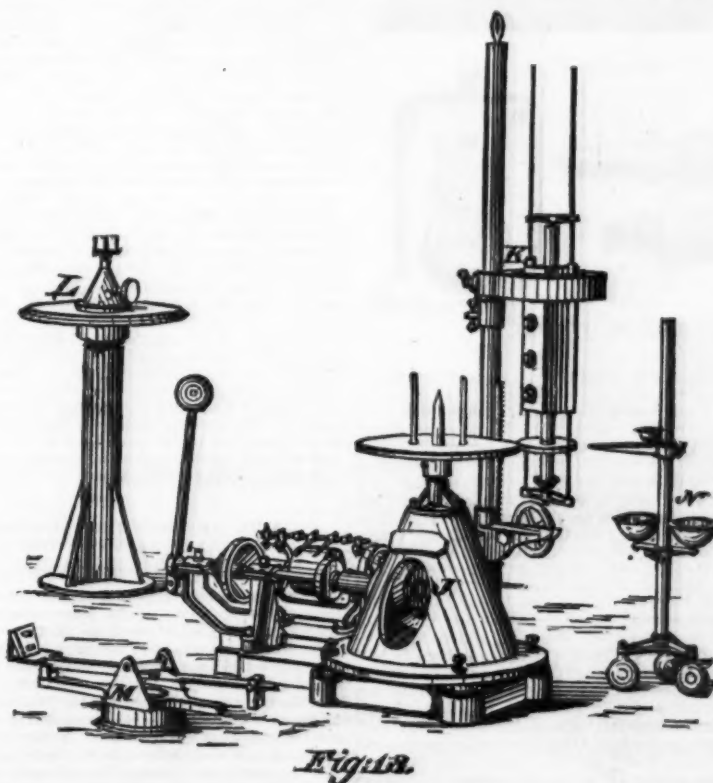


FIG. 12.

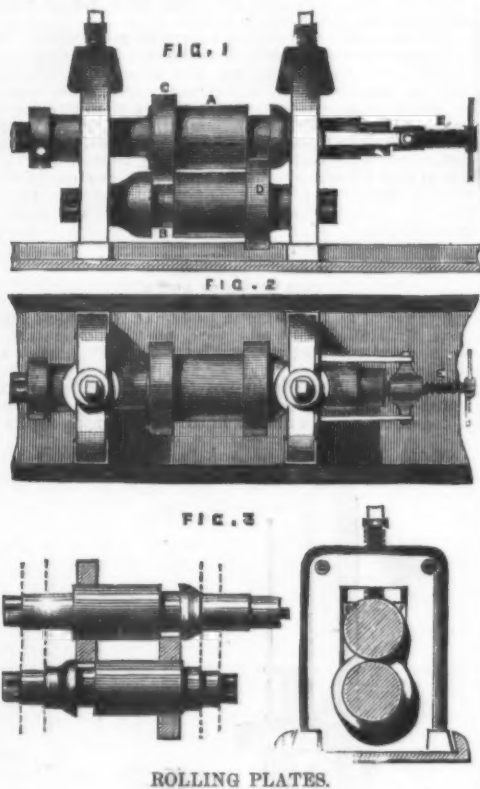
shaft in the direction of the over-weight, etc." This erroneous notion prevails among mechanics, and what wonder? when the professor's chairs hold nothing better. It is widely different from the latter portions of Maxims A and D. By experiment we learn that, in an unbalanced, rotating body, the point of greatest prominence is the point of greatest deficiency of weight. The journals of shafts, carrying unbalanced wheels or pulleys, will wear most on their light sides, and not, as is too often supposed, on their heavy sides.

Prof. Gillespie, of Union College, in a work on "Engineering Statics," when treating of solids in motion, as illustrated by a railroad train, in its production of dynamical deflection, while it passes over a bridge, says: "The extra stress is caused by the centrifugal force." He was making

angles, or other sections, and shows that much heavier blooms are necessary to make a plate of a given width than would be necessary to make the same plate if it could be rolled as a bar. In order to insure a perfect plate, it is necessary to allow say at least 3 in. on each side in a strip of fair length; so that for a 12 in. plate more than 30 per cent. of the rough strip is cut to waste on the edges alone. In other words, whereas a pile of 6 cwt. would be heavy enough to make a bar of a given weight 12 in. wide, a 9 cwt. pile would be required to produce a sheared plate of corresponding dimensions. With plates at \$8 per ton, and scrap iron at \$3 per ton, this extra waste would amount to a clear expenditure of over 80s. per ton in waste of materials alone. In order to overcome these objections to the prevailing method of rolling plates, at least as regards narrow plates,

the mill known as the "Universal Mill" was devised. It has also been called the Belgian mill from its frequent adoption in Belgium. In this country it has not been generally successful, owing chiefly to the difficulties which manufacturers in this country experience in adopting labor-saving machinery. The author, however, has had an opportunity of judging of its merits during several months' fair work at the Britannia Works at Middlesborough-on-Tees.

The Belgian mill is simply an ordinary mill with a pair of vertical rolls behind the horizontal rolls. These catch the plate as it leaves the horizontal rolls, and compress the edges sufficiently to close and solidify them. The surfaces of the vertical rolls move a little faster than those of the horizontal rolls. In practice it is not found desirable to compress the edge much more than is just about sufficient to preserve the width without decreasing it; and the plates are generally made about the same width as the finished plate is intended to be. This implies the necessity for great diversity of width in the puddled bars, a difficulty which is usually got over in Belgium by using several narrow bars of variable width to form the tops and bottoms of the piles. The manipulation of the Belgian mill is by no means a simple matter, nor can it be placed in the hands of inexperienced or unskillful workmen. The slightest maladjustment of the screws, either of the vertical or horizontal rolls, will cause the plate to twist; whilst if the vertical rolls are allowed to exercise any undue pressure on the edge, it becomes thickened to such a degree that the plate is sure to curve more or less the next time it is passed through the rolls, and any attempt to straighten it afterwards is generally useless. Under any circumstances the action of the vertical rolls is to a certain degree objectionable. The pressure, however slight, has a tendency to open the edge, and the thickening, which it is always difficult to avoid entirely, is for many purposes a serious drawback; as, for instance, when a number of plates of uniform width are placed in juxtaposition, as in the flange of a large girder. The advantages of the Belgian mill may thus be said to be confined to large establishments where more than one plate mill is in constant operation, and where a quantity sufficient for one mill of plates under about 3 ft. 6



ROLLING PLATES.

in. in width may always be selected from the orders in hand. Under such circumstances a very considerable saving may be effected. Figs. 1 and 2 show the general construction of a sliding roll mill, designed to accomplish the same object as the Belgian mill without being open to any of the more serious objections to the use of the latter. The construction of this mill may be thus described: The ordinary rolls of a plate mill are removed, and in the same standards a pair are substituted of the form shown on the drawing. It will be seen that the top roll, A, and the bottom roll, B, are nearly alike in form, and that a collar, C, is placed on the top roll, A, and a collar, D, on the bottom roll, B. These collars are not cast solid on the rolls, but are capable of sliding along them, being held, however, in one position as regards the other roll by corresponding grooves. Applied to the end of the top roll, A, is a powerful screw, E, which takes its thrust from the top chock, F, and consequently rises or falls as the top roll is adjusted in height. By working the screw, E, a motion in the direction of its length is given to the top roll, A, its necks being of such a form as to allow of this motion, whilst the bottom roll, B, remains firmly fixed endways between the standards. Attention to the drawing will show that end motion being given to the top roll, A, it will carry with it the collar, D, whilst the collar, C, remains stationary; and by this means the distance apart of the two collars is adjusted, being limited only by the travel allowed to the top roll, A, in the direction of its length. The drawing shows the form of box and spindle which has been adopted, and which has been found to present no inconvenience. The rolls are adjusted vertically in the usual way, but clearly they must not be allowed to open so far as to draw the collars out of the grooves. As the system is applicable to forge rolling, blooming, roughing down, and finishing, and to steel from the ingot as well as to iron from the pile, the author describes it in connection with the separate points in each requiring special consideration.

It is inconvenient to use very wide piles on account of difficulties connected with heating them; hence it will probably be found that rolls arranged for bars varying in width from 12 in. to 24 in. will meet all requirements. The collars and grooves would have to allow of a vertical adjustment of

about 5 in. (Fig. 3.) In some mills blooming could be advantageously combined with roughing down, and both operations done in the same rolls, the latter process being in fact but a continuation of the former. It is, therefore, necessary to have blooming rolls with a vertical adjustment in ordinary mills of about 5 in.; so that, taking a pile 12 in. deep, they would squeeze it down at once to 10 in., and then by successive adjustments of the rolls to a minimum thickness of 7 in., at which the roughing rolls are calculated to deal with it. Roughing down is simply a continuation of the blooming process. Provision has only been made for puddled bars up to 2 ft. wide. All plates above this width would have to be rolled with their length in the direction of the width of the pile. Finishing rolls are made with still smaller collars than the roughing rolls, the adjustment necessary being extremely limited, say from 1 in. to  $\frac{3}{4}$  in.; in other respects the rolls are of the same general form. It will be seen that it is impracticable to provide for more than a limited length of travel for the top roll in any case, but more especially is this true of the finishing rolls, where the pressure in rolling is greatest; otherwise the rolls would become dangerously small in diameter in proportion to their length. In practice it will probably be found that a travel of about 2 ft. will be as much as is convenient. So that beginning at 12 in. width, one pair of rolls would finish up to 3 ft. and all intermediate widths. Another pair would begin at 3 ft. and with a travel of 2 ft. would finish up to 5 ft., covering all intermediate widths. Where two mills were in constant operation, the one could be kept on the narrower and the other on the wider plates; but where only one was in use the rolls would have to be changed occasionally, probably not more frequently than once a week.

In the discussion which followed this paper, Mr. Jeremiah Head said that though the Belgians had sent a good many plates into this country rolled by the Universal mill, many of them had "reedy" edges, and apparently the difficulty which attends the attempt to weld up the edges of these wide flat bars had been noticed by engineers, as they were now but little used in this country. Making a large number of different widths of bar plates required an almost equally large number of different sized piles, and the method of overcoming this difficulty, as pursued by the Belgians, did not produce a satisfactory result. Mr. Head thought that bar plates would have very much less transverse strength near their edges, where strength is most wanted, than plates as usually rolled and with cut edges. In rolling iron, increase in superficial dimensions with decrease of thickness only takes place in the direction of the travel of the iron through the rolls, the breadth remaining practically the same. The material is, therefore, not so much worked transversely as longitudinally. In rolling plates the roller usually puts the plate into the rolls alternately by one and then by another corner, and so the material is worked in several directions. Common plates bearing, say, 22 tons longitudinal tensile strain, would usually break with a tensile strain across the grain of about 18 tons, and Mr. Head thought it was because the particles were much more intimately united in the direction of rolling than in the other. This view was, however, objected to by Mr. D. Adamson, who said that the tensile resistance in both directions would depend so much upon the regularity with which the cinder contained in the plate was distributed, and as common, or ship and girder plates, often contained from  $\frac{3}{4}$  to 4 per cent. of cinder, it was easy to see that want of uniformity in its dispersion would cause great irregularity in strength. In the direction of rolling the particles are rolled out and lie very much as a bundle of wires or a lot of needles, all lying in one direction, but slightly overlapping each other's ends. Thus longitudinal tenacity is not necessarily accompanied with equal tenacity in the normal direction. Mr. Head thought that the system of mill described would be better for steel plates, because it was easy to make ingots of any size, and the plates thereby sound at the edges. Mr. Adamson agreed with this. Mr. W. Webb said that in making steel plates at Crewe, they had been very successful in obtaining reliable plates, and had not found the difficulties often described as belonging to plates in that metal either as to cracking and corrosion. He attributed this partly to the method adopted for making them. Ingots 3 ft. square and of different thickness were used, and by hammering these in one direction only, by means of the Ramsbottom duplex hammers in use at Crewe, the honeycomb structure common in one part of the ingot is brought to the edges, and the part containing the flattened cells is thus cut off after the plate is rolled. Thus for rolling steel plates Mr. Webb thought the advantage of being able to roll clean-edged plates of any width might be attended with the same disadvantage as that described with reference to iron. The difference in the diameter of the rollers might lead to unequal heating and breakage more easily than with ordinary rolls, which a roller may break "first thing on Monday morning" by unequal heating. Mr. Cowper said he thought with care in preparation of piles and ingots, bar plates ought to be rolled by the new system, for the objections raised might also without care belong to simple bar rolling.

#### ON THE HARDENING, TEMPERING, AND ANNEALING OF STEEL.\*

##### I.—NATURE AND COMPOSITION OF STEEL AND CAST IRON.

KARSTEN, in 1827, says that carbon is contained in iron in three different ways: (1) As free carbon or graphite. (2) Combined with the whole mass of iron. (3) In the state of polycarburet, dissolved in the mass. In 1852, Jullien advocated, if he did not originate, the theory that iron and carbon do not combine (as true chemical combinations), but that the compounds formed by the two substances are what he terms "solutions," or, as we should translate it into English, only mechanical mixtures. Following Karsten, Berzelius, and others, he holds that amalgams and alloys are definite combinations, dissolved in excess of one of the components. He defines "combination" to be a union of elements in definite proportions, the resulting body being different from either component and from any of their other definite combinations. "Solutions," or mechanical mixtures, on the other hand, may occur in any proportions, and the resulting mixture participates in the properties of each component in proportion to its quantity. Your committee find it difficult to acquiesce in the latter portion of this statement. For example, the addition of increasing proportions of tin to copper results in producing harder compounds, instead of softer. Under certain circumstances, the addition of a small proportion of tin to cast iron greatly increases its hardness. Barba adopts Jullien's view, and defines steel to be a solidified solution of carbon in pure iron: (Les aciers sont des dissolutions solidifiées de carbone dans du fer chimiquement

pure.) Osborne seems to think that carbon exists both in a combined form and uncombined, disseminated in the latter case as graphite; but he does not define clearly what he means by the word "combined." Caron considers the union of the two substances to be a mixture. Gruner takes the same view. Akerman adopts the view that carbon occurs both in combination and as graphite; and also the view of Rinnman, that combined carbon may be partly intimately combined, when it may be called "hardening carbon," and partly incompletely combined, when it may be called "cement carbon." He does not define what he means by combination, whether in definite proportions or not. Your committee have not found any modern author holding the opinion that the various combinations of iron with carbon, and with other substances found in steel and cast iron, are definite chemical unions with excess of either one or other of the component bodies. The elaborate evidence adduced by Jullien, which does not appear to have been combated, makes it highly probable that steel and cast iron are only mechanical mixtures of carbon and some other substance in pure iron.

##### II.—QUANTITY OF CARBON IN STEEL AND CAST IRON, AND ITS STATE.

Barba considers that the solution of carbon in molten iron follows the ordinary laws of solution, that is: (1) The quantity of carbon which iron can contain in solution increases with the temperature. (2) By slow cooling, a part of the carbon separates from solution and is brought into a state of mixture. (3) With rapid cooling, or sufficient exterior pressure, the greater part of the carbon remains in "solution," rapid cooling acting by the pressure it produces; and, if the carbon is merely mixed, exterior pressure producing solution more or less complete according to the intensity of the pressure. (4) The temperature at which steel solidifies decreases as the quantity of carbon it contains augments. He remarks that experimental demonstration is wanting to show that pressure is favorable to preserving "solution" when cooling. Osborne says that rapid solidification favors the retention of carbon in the combined state, and by that means it is possible to change gray cast iron into white. Jullien states (1852) that the properties which the solutions of carbon in iron exhibit are due exclusively to the rate at which the hot solutions are cooled. Following Karsten, he says that the liquid solutions of carbon in iron are homogeneous, because rapidly cooled solid "solutions" are found to be so. He considers that: (1) Melted cast iron is a solution of liquid carbon in liquid iron. (2) Gray and soft cast iron is a solution cooled slowly, and converted into a mixture of mild steel and amorphous carbon or graphite. (3) Gray cast iron heated cherry red and plunged into cold water is a mixture of hardened steel and graphite. (4) White cast iron is a solution cooled rapidly, and consists of a mixture of crystallized carbon in amorphous iron. (5) White cast iron reheated, while protected from the atmosphere, and become gray and soft, is gray and soft cast iron. (6) White cast iron heated in contact with air, and gray or white iron reheated in closed vessels in a cement of metallic oxide, become mild steel. (7) Steel heated cherry red is a mixture of liquid carbon in solid iron. (8) Mild steel is a mixture of amorphous carbon in iron either amorphous or crystallized. (9) Hardened steel is a mixture of crystallized carbon in amorphous iron. He further states that iron absorbs carbon at temperatures ranging from cherry red to welding heat, and up to a quantity equal to 5.25 per cent. of the mixture; that the properties of steel approach those of iron in inverse proportion to the quantity of carbon; and that the presence of carbon not only increases the fusibility of the alloy, but communicates to it, in certain cases, properties belonging exclusively to crystallized carbon or diamond. He also states that the temperature of fusion of gray cast iron is higher in proportion as the quantity of graphite is greater, while the temperature of solidification is lower in proportion as the quantity of dissolved carbon in the fluid mass is greater. The lower, therefore, the temperature of solidification of gray cast iron, the higher is its point of fusion; it is only steel that has the same temperature of fusion and solidification. This property of cast iron is common to many bodies, such as bismuth, tin, sulphur, and water, under favorable conditions of cooling. Caron states that steel, if hardened by being heated to redness and cooled rapidly, and then dissolved in strong hydrochloric acid, leaves no residue; that the same steel, if raised rapidly to a red heat, and allowed to cool slowly, will, if dissolved as before, leave a residue of carbon, which dissolves on being heated; and that the same hardened steel, if annealed by being kept at a red heat for a long time, and allowed to cool slowly, dissolves more easily, but leaves a residue of carbon insoluble even in hot acid. The conclusions he draws are, that, in the first case, the iron and carbon are intimately united and dissolve together; in the second case the union is not so intimate; therefore, the more soluble body dissolves first, and the carbon, which is not quite modified, yields last; and in the third case the carbon is free, and shows it by its property of resisting acids. What Caron terms a solution of iron or carbon in hydrochloric acid appears to your committee to be probably a "double decomposition." Carbon is very unchangeable, resists the action of acids and alkalis, and bears the most intense heat in close vessels without fusing or undergoing any perceptible change. Baumhauer confirms these statements with respect to diamond, and relates the experiments by which they are proved. He also states that a diamond, when heated for a long time to whiteness in carbonic acid gas, showed prismatic colors on some of its facets. Akerman states that graphite is only mechanically incorporated in pig iron, and can be separated by dissolving the iron in acid. The combined carbon, on the other hand, when the iron is dissolved in boiling hydrochloric acid, escapes as carburated hydrogen, provided proper attention is given to the dissolving process so that the boiling commences almost immediately after the addition of the iron to the acid, and is continued uninterruptedly for a sufficient length of time without access of air. When dissolved in cold acid, and warmed a little time after, a part of the combined carbon remains as a black residue, especially if air has ready access. He also quotes Caron's and Rinnman's statements with respect to the solution of steel in acid. Gruner states that each temperature corresponds to a maximum of solubility, and that this solubility rises and falls both in the fluid and solid states. Whenever a carburated iron (steel or cast iron) cools slowly, an intimate mixture of iron and particles of graphite is produced, as in the case of untempered steel and gray cast iron. When carburated irons are cooled quickly, the separation of carbon is rendered impossible for want of time, and carbon remains dissolved in the iron at ordinary temperatures; saturation then results. The mixture then becomes hardened steel when the proportion of carbon is below 1.5 per cent., and white cast iron when above that quantity.

\* Reports to Research Committee of the Institution of Mechanical Engineers.

### III.—SUBSTANCES OTHER THAN CARBON ENTERING INTO THE COMPOSITION OF STEEL.

Dr. Siemens is of opinion that high-class steel should contain only iron and carbon: the hardness, temper, ductility, elasticity, toughness, and strength depending upon the relative proportion of these elements. But as it is almost impossible to produce such pure metal, other substances, which must, however, be considered as impurities, have to be admitted: these impurities have a certain influence in rendering steel hard, or rather in making it brittle; thus, if phosphorus is allowed, a certain dose of manganese has to be added to prevent cold-shortness, and a smaller quantity of carbon must be used. Manganese is a treacherous element in steel, as its distribution is not uniform, and thus a homogeneous compound is not produced. According to Fernie, a sample of Krupp steel contained 1.18 per cent. of carbon and a trace of manganese, and a sample of American steel 0.28 per cent. of carbon and no manganese; the latter constituted soft metal fit for fire-boxes. Frémy (1844) advanced the theory that nitrogen was an essential component of steel; that steel was, in fact, a nitro-carburet of iron. Carbon, however, considers it proved that all kinds of iron contain feeble quantities of nitrogen, 0.00011 per cent., and considers that it must be looked upon as an impurity just like silicon, sulphur, and phosphorus. According to F. C. G. Müller, it has been proved that hydrogen, nitrogen, and carbonic oxide are to be found in the pores of Bessemer and Siemens-Martin steel. Cyanogen, tungsten, chromium, platinum, silver, and other substances have been mixed with steel with a view to give it certain high qualities; but Chernoff, Dr. Siemens, and many others are of opinion that true steel is a mixture or combination of carbon and pure iron alone, and that all other substances are impurities necessarily injurious in pure steel, though sometimes apparently beneficial if they exclude or neutralize more injurious substances. Boman states that Bessemer steel No. 1 (which is necessarily impure), containing only 2 per cent. of carbon, is hardly malleable; while Anosoff found that the hardest "boulat" (the saber steel of the Tartars), which is perfectly pure, retained its malleability though it contained 3 per cent. of carbon.

### GAS AND ELECTRICITY IN PARIS.

SINCE the Jablochkoff light was established for the first time in the Avenue de l'Opéra, it may be said that there has been in Paris a regular competition between gas and electricity. The "Compagnie Parisienne d'Eclairage et de Chauffage" by gas is certainly one of the largest in existence, as it possesses every gaswork in Paris, and almost every one in the vicinity. A system of subterranean pipes and valves connects all these establishments, so that gas generated in Courcelles can be sent to any part of the city and suburbs, if required. All these different works were conducted as separate establishments before the fusion which took place in 1854, under the auspices of the then existing Imperial government. Two of these establishments are worthy of note—La Villette, as being the largest, the site of experimental and chemical work, and Vaugirard, where the retorts are warmed by the Siemens heat-generating process.

Each of the twenty arrondissements of Paris has its special gas office. The company also sells gas-engines, and makes great efforts to develop the use of gas as fuel for warming and cooking in private houses and shops. The price of gas is dearer in Paris than in any other capital of Europe, and the arrangements are difficult to understand without an explanation of the French municipal institutions.

The cry for more light having been raised in consequence of the experiments conducted with electricity, a new gas burner has been invented by the Compagnie Parisienne and placed experimentally in several large public thoroughfares, principally the Rue du 4 Septembre, the Place de la République, formerly Place du Château d'Eau, and a pavilion in the Halles Centrales. The burners used in the Rue du 4 Septembre are the largest, and all the new burners have been constructed on the same principle. The ordinary wing burners consume about 120 liters of gas each hour. In these improved lanterns six burners, representing an hourly consumption of 1,400 liters, have been placed at the six summits of a hexagon. In the center is a hole for facilitating the introduction of air and better consumption. The effect is really highly satisfactory, and the luminous effect is far greater than in proportion to the gas consumed. A large number of coffee-houses, theaters, and first-class shops have adopted the burners for exterior use. It is impossible to use them within any building except markets, owing to the immense quantity of heat radiated, which would be a nuisance, at least in summer time. A number of these improved gas lamps have been placed in the Lyons railway station (passenger department), and will be, within a few days, used for competitive experiments with the Lontin electric light.

Beside the hole for admission of air, a gas pipe is placed in the central part of the lamp. The aperture has been disposed so that a small jet is always burning, and thus, for lighting the lamp, it is sufficient to open the valve of the gas pipe, and the six peripheral burners are lighted at once. After midnight the jets are extinguished and the central one opened, burning with a consumption of 120 liters per hour, or like an ordinary old gas burner. The supplementary gas consumed by the city is paid for at a very cheap rate, about 1s. 6d. per thousand cubic feet. It must be said, moreover, that the Chambre Syndicale des Tanneurs and other commercial institutions have organized an agitation to oblige the municipal corporation to diminish the price of the gas. The commission of the municipal council is at present deliberating upon that important question. A large factory, the Say Sugar Refinery, close to the Orleans Railway Station, built a private gaswork for its own use. They consume yearly about 6,000,000 cubic feet, and will turn their own gas-makers.

In electrical lighting the division principle is represented in Paris by the celebrated Jablochkoff candle, and a diversity of opinions have been expressed on the subject. The apparatus in itself requires no description, but it is necessary to explain the results which have been obtained.

The Jablochkoff light placed in an opal globe is considered as perfectly suited to large shops and large public thoroughfares, although the diminution of light by the interposition of the globe may be valued at 45 per cent. The price of effective light is enlarged in the same proportion. This is the reason why many persons suppose that, from an economical point of view it will never do except in large open places, as the Place de la Bastille, where semi-transparent globes are used without fear of any complaints from shopmen or street passengers. But even for illuminating these large places, it is supposed by many competent persons that

other electric lights would be more successful, and at all events more economical. The only place where the Jablochkoff candles can be considered as unrivaled are large establishments like the Grands Magasins du Louvre, the Buttes Chaumont, and the Ville de France, where the effect obtained is alone considered without much regard to the expense. The illumination of the Palais de l'Industrie during the evening sittings of the Exhibition of Fine Arts, was a success last summer. It was not attempted a second time during the Exhibition of Sciences Applied to Industry, owing to several circumstances, having nothing to do with the value of the system. At the Hippodrome, the illumination is effected by a combination of gas lights and Jablochkoff candles, and ordinary regulators with luminous points carefully concealed. The general effect is quite satisfactory, but the expense in motive power is considerable.

Jablochkoff candles are used in the illumination of large works carried on at present on the Seine, for repairing the Pont des Invalides. These works have been interrupted for the last month, owing to the frosty weather, but the Jablochkoff light has worked admirably. The use of the Jablochkoff candles is progressing immensely in private establishments, although the municipal council will, in all probability, discontinue the electric lighting of the Avenue de l'Opéra, the Place de la Bastille, etc., from February 1, and keep it burning only on the Place de l'Opéra. This impending resolution is attributed to the prevalence of the gas interest.

In the first months of the Jablochkoff trial many complaints were made against the irregularities of the light; now extinctions are almost unknown, and the red color of the electric flame less frequent.

Extensive preparations have been made in the green room of the opera for a comparison between Jablochkoff and Werdermann candles, and will be completed in a few weeks. It is argued by Werdermann's opponents that his light is merely incandescent light, and that the loss of illuminating power is far greater than with the Jablochkoff system. M. Garnier, the architect, being intrusted with the task of reporting on the matter, it would be unbecoming to give an opinion before his verdict is published. M. Reynier has another incandescent light, offering some analogy with Werdermann's, but the contact being more intimate, the loss in power is larger, and the public exhibition of it has been considered a failure. It is regarded as merely an apparatus for lecturers wishing to show their audience an electric light with few elements. The lamp is cheap, and its working quite regular.

It should not be forgotten that even naked Jablochkoff lights lose a part of their illuminating power. A quantity of electricity, which may be valued at 30 per cent., passes through the insulating kaolin or plaster. Consequently, it must not be wondered at, if some inventors tried to dispense with insulating lamina.

M. Denayrouze, the former lessee of the Jablochkoff candle, has purchased the Jamin candle, in which the electric flame is directed by the attractive power of magnetism or electricity. Private experiments have been made, and they are preparing for an exhibition in one of the suburbs of Paris. M. Jamin, having to lecture at the Sorbonne on January 17, it is probable that the large hall will be illuminated by his own light on this occasion. This light company has purchased a patent for gas engines, and will try to use the gas under the furnace as fuel, dispensing with it for illumination. They are said to contemplate a public issue of shares for a large capital.

It is known that the principal difficulties in the construction of regulators has always been the absolute fixity of the luminous point in space. It has led M. Serrin to the invention of his excellent regulator. But the use of the Jablochkoff light proved that inventors had gone too far in the way of complication, at least for street illumination, and where no dioptric or catoptric arrangement is contemplated. M. Suisse was the first to start a lamp which may be regarded as a simplification of Serrin's original, and is working very well. The carbon is placed upward, and descends in proportion as the negative is consumed. In order to diminish that consumption the diameter of the negative carbon has been enlarged.

A number of regulators have been tried in competition, or will be, but Suisse's is now the only one which works regularly at the Lyons railway terminus, in conjunction with a few Lontin's regulators and with Lontin's generator. The results of the illumination are quite satisfactory, eighteen lamps being fed at an expense of 36 kilogrammes of charcoal per hour during fifteen hours every day, and with an expense of 9 francs per hour, including three francs of royalty for the Lontin Company. When this extensive space was illuminated by gas, the expense, at 19 centimes per cubic meter, was 6 francs per hour, and would have been 9 francs if the gas were charged 30 centimes, or the full price. The economy for the company results from the immense augmentation of the light distributed. They were enabled to diminish by 70 per cent. the number of hands engaged in night work, and the risks from fire are reduced to nothing. Lontin's system will be tried within a few days, in competition with improved gas, on the platform of the passengers' department.

At the exhibition of the Palais de l'Industrie, Lontin's machine is working regularly every day from two to the closing hour, which varied according to the hour of sunset. No accident has been recorded. Siemens' machine has been very seldom at work, owing to several circumstances which prevented the public from making a direct comparison. The engineer of M. Siemens' factory having been selected as one of the jurymen, Siemens' machine was, *ipso facto*, out of competition; consequently we will not risk giving any definite opinion at present, confining ourselves to known facts. We visited Siemens' light at the works established by the universal firm at Passy, and we were very much satisfied with the effect which we witnessed. The illuminating power and regularity were out of question.

All the work of the Jablochkoff candle is done with Gramme machines, which have been fitted with a current inverter.

Lontin, Suisse, and other regulators are worked with continuous currents, which is considered as more advantageous.

Three different magneto-electric generators are before the public: Gramme, Lontin, and Siemens, based on similar principles, having a strong similarity in many respects, each of them claiming priority. We cannot presume to give a definite opinion on their special value, or on the value of their respective claims. The question can only be settled by the city or the government deciding for the illumina-

tion of some part of the city, or some large public buildings.

We can state, at all events, that the Meritens Company has started new machines, which we witnessed working with regularity at the Continental Hotel, on the occasion of a great ball; that the Alliance machine, although excellent for lighthouses, has proved too heavy, too expensive, and too cumbersome for ordinary purposes. The Lontin machine is rotated at a rate of 200 or 250 turns per minute, and its rival, from 700 to 800, which is a decided advantage in its favor.

It is not our province to adjust the claims relating to the manner of exciting almost any number of currents with a single generator, and an electro-magnetic divider. But all the visitors to the Palais de l'Industrie, have been astonished by the regularity of the Lontin light and its facility of combining the several arcs.

The other day the Ouest Railway Company established in the terminus of La Rue Saint Lazare three rival lights: Lontin, Parisian Company's improved lights, and Jablochkoff candles.

We decline to give a definite opinion of the respective merits of the Lontin and Jablochkoff systems before the moment when the numerous measures officially taken with a new photometer and the expenses in coals, electric carbon, and oil will be made public; but we can say that gas-light seems to be one-third dearer, and one-half only in general intensity.

Some of the great expectations raised when the Jablochkoff light was first exhibited, have proved groundless. The shares of the gas companies have recovered from their depression, and reached at least their former value. But it cannot be said gas has conquered electricity, as electric lighting, with all its variety of origin and regulation, is gaining ground daily. Siemens' agents are at present fitting a large factory at Meaux with their regulators and generators. The works of installation of the Senate Chamber of Deputies would have been impossible without the help of the electric light. A new influential daily paper, *Gil Blas*, has opened on the Boulevard de l'Opéra and "Halle aux Nouvelles," with no less than eight Jablochkoff candles. There is no part of Paris where electric lighting has not been exhibited, and its appearance is no longer a novelty, which is an all-important thing for its propagation.

In the meantime, there are other inventors trying to generate electricity by new means. M. Beaudet has started a bichromate battery which he calls *unpolarizable*, perhaps without any real ground, but which, at all events, keeps in tolerable regulation for many days. M. Clamond has continued to produce a real electric light out of a series of thermal elements, which was considered a mere impossibility a few months ago. We cannot say if the scheme of lighting by electricity out of a stove which warms an establishment, or a furnace which creates steam, is a Utopia, but we witnessed, during some hours, a light generated by the Clamond process, and a large workshop uses no other lighting process during the present winter.

The Municipal Council of Paris should open a public competition for lighting a large place or building, and invite all inventors of regulators and magneto-electric machines to place their apparatus in the hands of a competent commission, otherwise the question of electric lighting will remain in the dark for years, as it will be impossible for private individuals to decide which is the cheapest light produced and the best regulator.—W. de Fonvielle, in *Nature*.

### THE ESSENTIAL NATURE OF ELECTRICITY.

BY J. T. SPRAGUE.

MR. FITZGERALD will undoubtedly tend to produce a more definite and general conception of electricity and of electrical force by means of his interesting series of "Contributions to a Physical Theory of Electricity," even if he does not succeed in convincing any one of the existence of electricity as an actual entity, fluid, or form of matter, ponderable or otherwise. It was my intention to await the conclusion of those papers before making any remarks thereon, or in reply to the column of criticism on my own views, which my friend devoted to them, p. 20, Nov. 29th. But, after all, I do not mean to discuss Mr. FitzGerald's propositions at present, but simply to show that there is not, in my own theory, either the hiatus or deficiency asserted, or the failure to occupy the ground which Mr. FitzGerald seeks to occupy by his theory. Therefore, there seems no good reason against at once explaining these points, and showing that my own theory, when fully understood, is in perfect accord with all the rest of that physical theory of electricity which Mr. FitzGerald is working to develop, and does actually fulfill the exact functions which he considers necessitate the existence of an actual electricity, a fluid or form of matter. I am moved to writing at this time by a statement, on p. 33: (c). If the quantity be a form of matter, it is acted upon by force, and constitutes a *vehicle for energy* with which and from which it may be alternately associated and disassociated. But its conversion into energy or any mode of motion will be a matter of absolute impossibility, and, consequently, it can have no mechanical equivalent, or will not be susceptible of being expressed in terms of any unit of work.\* Most true. Turning back now to p. 33, we find these words, "We can arrive at the logical form of the proposition, which in reality underlies the views which have sometimes been erroneously dignified by the title of 'The Dynamic Theory of Electricity,' viz., the form which directly denies the objective existence of any thing corresponding to that which is apparently measured by the voltmeter or galvanometer, and which is expressed by the formula  $\frac{E}{R}$  or  $\frac{I}{R}$ ." On p. 34 we find the distinction

between the values expressed in formulae as  $\frac{E}{R}$  and  $\frac{E}{R}$  and the statements made that the first of these is "material or analogous to matter, and may be represented to the mind by the expression, imponderable fluid." Again, "There is an electrical energy necessarily equivalent to  $\frac{E}{R}$ , which is the true cause of electrical phenomena, and which may be converted into heat and work."

I see and maintain this most important distinction as fully as Mr. FitzGerald; it is not dealt with in the general vague ideas of electricity as a "mode of motion," and in the quotation from Prof. Barrett, p. 34, the two are so mixed up as to result in absolute error, for "the missing quantity having been converted into heat" is a pure mistake. Electricity—that which is measured by  $\frac{E}{R}$  (that is to say C or current)

\* It shows that a Jablochkoff candle placed in an opaque globe is diminished (1) 0.70 by the loss of the kaolin, and (2) 0.50 by the opacity of the globe, so that it gives only 0.35 of the original illuminating power.

is never converted into heat or work, or into anything whatever.

But in what I have called in my work the dynamical theory of electricity, though I deny the objective existence of any thing corresponding to this value,  $C$ , that is to say a fluid, yet I have provided an agency which does accomplish all that is involved in  $\frac{E}{R}$  as distinct from  $\frac{E^2}{R}$ , and does all that the supposed "fluid" is invented to do without our having to create this additional and unknown form of "matter." This, then, I now propose to fully explain, in order that this idea may be used concurrently with all the other principles in the physical theory of electricity by simply substituting it for the idea of the material fluid. To fairly compare the various theories of the actual nature of electricity, it is necessary to bear in mind the process by which those theories grew into existence. The first knowledge obtained of electricity was of its static actions, the apparent phenomena of generation or separation from matter, charge and transfer from one vessel to another; these phenomena do bear so strong a resemblance to similar operations with gases that it was almost inevitable that their cause should be attributed to a substance similar in character to gases, though incapable of actual appreciation except by its actions.

When current electricity was discovered and grew into importance, much labor was expended in fitting the old theories to the new facts. But these were much less adapted to them, and there can be little doubt that had current electricity, with its chemical and magnetic relations, been the first to be thoroughly examined, and especially if this examination had been deferred until some clear ideas had been obtained of the nature of force and energy, the fluid theories of electricity would never have come into existence or found much acceptance. For this reason it appears to me that we need to reverse the old process and to give our attention mainly to the phenomena of current electricity. In fact, it is here only that we can trace the connection between electricity and matter, for here we find that there is an absolute relation between what we call electricity and the molecular and equivalent constitution of all material substances, a relation which is by no means apparent, indeed requires to be traced out in the phenomena which we call the actions of static electricity.

Let us then examine the fundamental facts of the current. We find, first, two phenomena perfectly analogous to those of any material current, which may be very fairly compared to the passage of water through pipes. These are (1) an apparent transfer of a "quantity" (be it what it may) which we express in formulae as  $C$  or "current," and which is de-

fined in the accepted formulae of Ohm as  $-\frac{E}{R} = C$ . This is, in fact, perfectly analogous to the pint or pound, gallon, or cubic foot per minute of hydraulic formulae. We have also (2) a transfer and expenditure of energy related to  $E^2$  or  $C^2$ , which is also perfectly analogous to the energy transferred and expended by a current of water. If we take closed circuits or currents, including the generator of currents in both cases, electric or hydraulic, the analogy is perfect, as I have shown by diagram and reasoning, p. 204 of my "Electricity; its Theory, Sources, and Applications." But besides these two facts we have also (3) an external action called Tension, and measured as difference of Potential, also analogous, as I have shown, to the pressures in the pipes of a closed hydraulic system. Here, however, this mechanical analogy ceases, and we come upon phenomena peculiar to electricity, for we find that this dynamic current has actions outside of itself. (4) Static induction effected in one direction as the current commences to move, and in the other when it stops, but incapable of doing any work while the current is actually passing. (5) Magnetic induction, by which the magnetic state and force is set up in matter, by which work is done by the current while passing, and by which the energy of the current is actually absorbed and expended in external work; and (6) chemical action set up within the circuit of the current itself, and bearing very remarkable relations to the "quantity" of the current, explainable only on the ground that this "quantity," be it what it may, is absolutely dependent upon the molecular constitution of the matter transmitting the current, and not, as in the case of water, upon the mass or measure of any "matter," the motion of which constitutes the actual current itself. It is the last set of facts which are inconsistent with the conception of electricity as a matter of fluid.

In Fig. 1, I endeavor to show the merely mechanical or material idea of a current. It may be considered as a length of a pipe or conductor; each square represents a unit of "quantity," a pound or gallon of water, or an electric unit, so that "current" will be measured by the number of units passing across the middle line per second. This is the quantity,  $-\frac{E}{R} = C$ , and this quantity of current (in a closed cir-

cuit) will be equal in every section of the circuit, whether this be a single conduit, or divided into many. By the well-known laws alike of hydraulics and electricity, the energy needed to set up this current, and the energy transmitted and expended by the current will be as the square of the current  $C^2$ , or (as  $C$  is always proportional to  $E$ , or force, as defined in the various cases) it is represented by  $E^2$ . Thus, we have in plain view those two quantities insisted upon by Mr. Fitzgerald, the one a moving fluid or matter; according to him, an agency; as I seek to show, unchangeable and inconvertible into anything else; the other, energy capable of transfer and transformation.

Looking at Fig. 1, we understand at once that each single



quantity, the unit velocity of which constitutes the unit of energy, will give these two results, a quantity of current varying as its direct ratio of motion, and energy or work varying as the square of its ratio of motion.

Fig. 2 represents another idea of a conductor of energy,



consisting of a series of wheels connected together, so as to move equally on their axes without change of place. If we now conceive that each single rotation of a wheel is our measure of "quantity," instead of the actual motion of transmission, as in Fig. 1, we have precisely the same results.

We still measure by a number or quantity arrived at by precisely the same formulae; this "quantity" will vary as the direct number of rotations, and the energy absorbed and transmitted will vary as the square of the rotations. We have substituted a simple "mode of motion" inconvertible into work, not expressible in terms of any mechanical unit, for the matter or fluid possessed of these functions, and yet we have the same quantitative results, and the same "energy" capable of transformation.

In Fig. 3 we have the same principles in another form

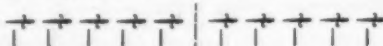
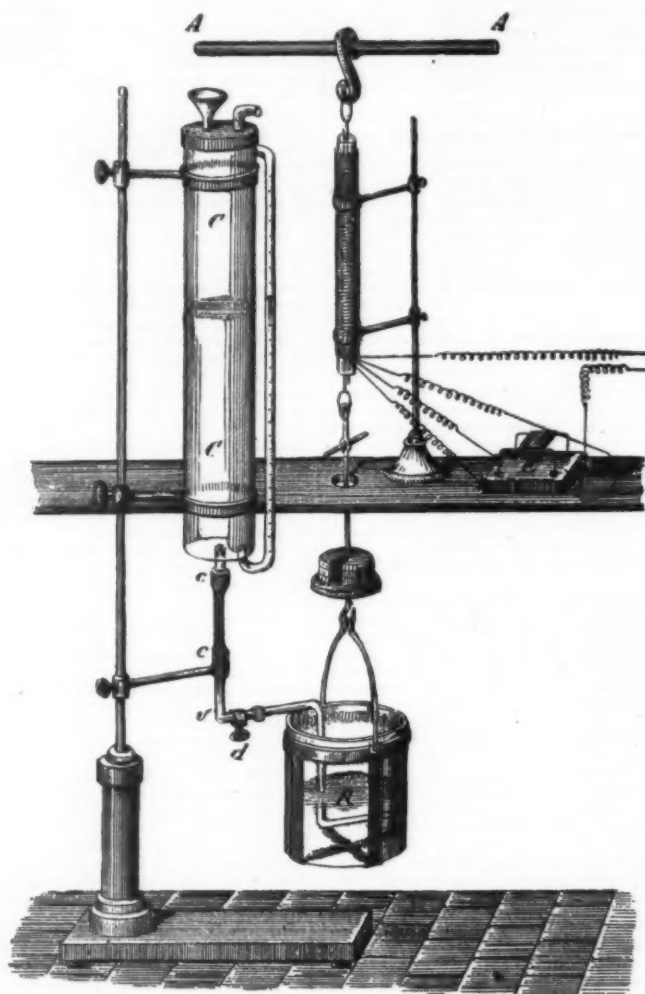


FIG. 3.

series of magnetic needles on centers, which will rotate and transmit energy in a manner similar to the wheels in Fig. 2. Practically, of course, that is, as a machine, this plan would not work as perfectly as the wheels, but it serves as a means to carry our ideas from the rough mechanical stage into the field of molecular physics. We see by it that energy is transmissible by means of a "mode of motion," which is not itself energy, and which produces the effects of current without the transfer of matter, while still we have the same two important factors as before.

#### THE INFLUENCE OF MAGNETISM ON THE TENACITY OF IRON.

The following is a translation of a memoir recently published in the *Rivista Scientifico-Industriale*, by Emilio Piazzi, Assistant Professor of Physics in the University of Catania, Italy.



#### INFLUENCE OF MAGNETISM ON THE TENACITY OF IRON.

Many physicists have undertaken the study of the relations existing between the mechanical and the magnetic properties of iron and steel. Among all these, the researches of Wiedemann into the reciprocal influence of torsion and magnetism are the most interesting, because they are the most complete. (See his "Lehre v. d. Wirkungen des Galv. Str." 2d ed., p. 547.)

As for the other relations between the magnetic and the mechanical properties of these bodies, it would seem that the problem is not completely solved, although many researches have been made, because some doubt still remains concerning the accuracy with which the difficult experiments involved in them have been conducted.

Professor Macaluso had intended, together with myself, not only to repeat such experiments as still admitted of doubt, but also to attempt some entirely new ones, as, for example, to determine what influence permanent or temporary magnetism would exert on residual elasticity, the *elastica Nachwirkung* of the Germans.

The unfortunate condition of the laboratory, the lack of instruments for precise measurements, and the absence of means for the purchase of materials, made it necessary for us to abandon our purpose, at least for the present.

However, as scanty means will sometimes suffice to carry on our approximate study, Professor Macaluso advised me to investigate the influence of temporary magnetism on the tenacity of iron, a task which I most willingly undertook. The results obtained seem to me of sufficient interest to warrant their publication.

#### METHOD OF RESEARCH.

The experiments were performed according to very nearly

the same method as those instituted by Prof. Planté to determine the influence of temperature on the tenacity of iron and other metals. (See "Atti della Soc. Ital. delle Scienze" Serie III., Tomo III.; also "Memorie dell' Accad. dei Lincei," Anno CCLXXIV.) The difference is, that we have here arrangements suitable for magnetizing instead of heating the wire.

The apparatus used is represented in the annexed figure. A A is a bar of iron firmly fixed in the angle formed by two walls. An iron hook attached to this bar carries a thinner hook of copper, about six centimeters long, two centimeters of which hang down into a glass tube surrounded by a coil of wire. The iron wire to be tested is fastened to the copper hook above, and is provided at its lower extremity with another copper hook precisely similar. Thus the whole of the iron wire remains surrounded by the magnetizing coil, even after it has been stretched. The lower hook is fastened to an iron rod, the other end of which carries the weights, and also a water receiver, R. The rod passes through a hole in a horizontal shelf, and is prevented by a small crossbar from descending too far when the wire breaks.

C C is a tall and narrow glass vessel, graduated accurately to cubic centimeters, and filled with water. By means of these graduations, the volume, and, consequently, the weight of the water is easily determined, which flows out and is conducted into the receiver, R, by means of a rubber tube, e e, and a glass tube, c c, several times bent at right angles. The latter is drawn out at its end so as to leave only a very small aperture, from which a fine stream impinges upon the side of the pail, R. In this way the effect of the impact is rendered so small that it may safely be neglected. A stopcock, d, serves to regulate, and, if necessary, to interrupt the flow of the water.

The whole apparatus having been put together so that the wire is suspended from the upper hook, and bears, in turn, the weights and the receiver attached to its lower extremity, the cock, d, is opened and the water is allowed to flow into R, until the wire breaks. Then the weight of the water that has flown out of C C, added to the weight of the iron rod, the pail, and their accessories will represent the breaking weight of the wire.

The problem now is to determine what difference, if any, is produced in this weight by magnetizing the wire.

Since the changes of temperature due to the passage of the current in the coil greatly influence the tenacity of iron, it was necessary to find some means of avoiding this source of error. The first plan that suggested itself was to cause a current of cold water to circulate around the wire, but the difficulty of constructing a suitable piece of apparatus necessitated the adoption of simpler, and, perhaps, more efficacious means. It consisted in causing the wire of the coil to be constantly traversed by the same electrical current and in producing magnetization at will.

For this purpose the coil was made up of four layers, and the current was caused to pass in one direction through the first and fourth, while it passed in the opposite direction through the second and third. A commutator, E, was added, by means of which the direction of the current in the second and third layers could be reversed. It is plain that the heating effect would always be the same, no matter what the direction of the current, provided its intensity remained the same; while, by simply reversing its direction in the second and third layers, the iron wire could be magnetized either powerfully or hardly at all.

The experiments were made with wires prepared under

different conditions, to wit: wires annealed with charcoal, wires annealed in carbonic anhydride, and wires annealed in hydrogen.

In every case the wires were left at a red heat for about ten minutes, and were then allowed to cool very slowly. In carbonic anhydride and in hydrogen the process was conducted in an iron tube traversed by the gas and kept in continual rotation, while it was being heated in an apparatus like that employed by chemists in organic analysis.

I had also attempted some experiments with unannealed iron wires, but I was baffled by the same difficulty as that encountered by Prof. Lissac in a similar case, namely, that the wires always broke at their points of contact with the other parts to which they were fastened, no matter what might be their form or material. I was, therefore, obliged to give up these experiments.

To fasten the iron wire to the two copper hooks, and to introduce it in the tube, I doubled about four or five centimeters of the end, doubled this portion again, and twisted the double end so formed spirally around the end that contained the long wire.

In this way it never happened that the wire broke where it was attached. The other extremity was treated in the same manner, taking care to keep the same length of wire in all cases between the two little rings thus formed at the ends.

I then lifted up one of the hooks by means of the lower ring, passed the whole up into the tube, and attached the other hook as soon as the upper end of the wire made its appearance. The wire was then wholly inside the tube.

This operation could be performed quite rapidly, and had the advantage that all the wires could be prepared beforehand and promptly replaced during the course of the experiment.

To obtain satisfactory results, I adopted the method of averages, since the wires, although cut from the same coil, scarcely ever have the same breaking weight, on account of slight differences of section or structure.

From each coil of wire to be tested, I cut all the samples necessary for each series and placed them in rows. Then I formed them into groups—the first, by taking wires 1, 6, 12; the second, by taking 2, 7, 13, and so on. The groups of each series were thus mixed, so as to eliminate to a great extent the influences due to the variations just mentioned.

After having cut a series of wires annealed with charcoal, and arranged them in two groups of 16 each and one group of 20, I thought it expedient to take into account the difference of elongation. So I measured each wire after attaching it to the hooks, and before any weight was put upon it, by the somewhat crude means of a ruler divided into millimeters and half millimeters. After the wire was broken, the two pieces were similarly measured. Calling  $l$  the original length, and  $l'$  the final length, the fraction  $\frac{l-l'}{l}$  =  $L$  will give the coefficient of elongation.

#### RESULTS OBTAINED.

To give an idea of the differences shown in the rupture of wires belonging to the same group, I will report in detail the results obtained with a group of wires annealed in carbonic anhydride and with another annealed in hydrogen.

#### GROUP 4 OF WIRES, ANNEALED IN CARBONIC ANHYDRIDE.

1 meter of the wire weighs 0.264 gramme.

Magnetized.			Not Magnetized.		
Breaking Weight.	Initial Length.	Final Length.	Breaking Weight.	Initial Length.	Final Length.
1733 grm.	166 mm.	185	1693	167	196
1743 "	166 "	188	1703	169	195
1733 "	168 "	186	1718	170	196
1719 "	168 "	190	1698	166	190
1723 "	167 "	188	1708	170	197
1743 "	163 "	183	1703	165	188
1738 "	164 "	185	1708	165	195
1738 "	165 "	188	1713	162	187
1723 "	166 "	187	1740	165	188
Mean.					
1733 grm.	165.88	186.66	1709	166.55	192.46

#### GROUP 3 OF WIRES, ANNEALED IN HYDROGEN.

1 meter of the wire weighs 0.285 gramme.

Magnetized.			Not Magnetized.		
Breaking Weight.	Initial Length.	Final Length.	Breaking Weight.	Initial Length.	Final Length.
1333 grm.	165 mm.	197	1248	162	188
1318 "	165 "	194	1263	163	190
1308 "	164 "	195	1258	166	189
1283 "	165 "	195	1273	165	190
1283 "	165 "	194	1258	163	187
1280 "	165 "	194	1258	166	189
1278 "	164 "	195	1283	164	194
1278 "	167 "	193	1238	165	189
1288 "	164 "	188	1278	160	189
1283 "	164 "	189	1278	165	190
Mean.					
1292 grm.	164.8	193.4	1265	164	188

The following three tables contain a résumé of the results obtained.  $N$  indicates the number of wires contained in the group;  $P$  is the breaking weight in grammes of the magnetized, and  $P'$  that of the unmagnetized wires;  $L$  and  $L'$  are their coefficients of elongation respectively;  $M$  and  $M'$  are the corresponding maximum weights found in each group, while  $m$  and  $m'$  are the minima.  $M$  and  $m$  belong to the magnetized, and  $M'$  and  $m'$  to the unmagnetized wires.

#### WIRES ANNEALED ON CHARCOAL.

1 meter of wire weighs 0.29 gramme.

N	P	P'	L	L'	M	M'	m	m'	Observations.
16	1260	1213	47	60	25				Battery of 10 cells freshly charged.
16	1297	1270	27	50	60				Same battery as before.
20	1306	1260	46	52	40				Same battery with fresh charge.

#### WIRES ANNEALED IN CARBONIC ANHYDRIDE.

1 meter of wire weighs 0.264 gramme.

N	P	P'	L	L'	M	M'	m	m'
16	1742.7	1703.62	39.14	1626	1257	0419	51	5
18	1737.0	1710.11	26.99	1229	1012	0218	15	25
16	1735.0	1719.87	15.13	1370	1300	0070	—5	5
18	1733.0	1709.33	23.67	13.0	1540	0024	13	25
20	1732.4	1715.00	17.40	1473	1422	0051	20	17
20	1739.5	1707.50	32.00	1368	1497	0029	45	25

Observations.—The battery used with the first group above consisted of 10 cells, and was freshly charged with acids; the same battery was used for the second and third groups without renewal; for the fourth the nitric acid was renewed; no additions were made for the fifth group; and, for the last, a new battery of 10 cells was employed.

#### WIRES ANNEALED IN HYDROGEN.

1 meter of wire weighs 0.285 gramme.

N	P	P'	L	L'	M	M'	m	m'
20	1310.1	1299.7	10.4	1032	1368	0316	5	20
20	1303.0	1277.0	26.0	1255	1109	0146	35	30
20	1292.2	1263.0	24.2	1728	1556	0172	50	30
20	1330.0	1281.5	48.5	0102	0307	0059	100	15
20	1289.5	1263.0	26.5	1412	1107	0305	30	30

Observations.—The battery used for the first group consisted of 10 fresh cells; for the second, of 12 fresh cells; for the third it was the same as for the second, with the addition of nitric acid; for the fourth it consisted of 13 fresh cells, and this latter was afterwards used for the fifth group.

#### CONCLUSIONS.

An attentive examination of these tables seems to me to warrant the conclusion that the tenacity of magnetized soft iron is greater than that of soft iron not magnetized. If I had contented myself with examining only one or two groups of experiments, I might not have been able to come to this conclusion, since, in every group, the difference between the breaking weights of magnetized and unmagnetized wire ( $P-P'$ ) is frequently less than the difference between the maximum and minimum values ( $M-m$ ,  $M'-m'$ ) of the weights necessary to produce rupture in apparently identical wires and under the same conditions.

However, as the mean values of all the 14 groups of experiments are uniformly greater in the case of the magnetized wires, I believe myself warranted in asserting that the difference is due to the influence of magnetism. This assertion is confirmed by the fact that in every group, 28 cases in all, the differences between the maxima and between the minima ( $M-m$ ,  $m-m'$ ) are positive quantities, with but a single exception. In this exceptional case there may be some source of error, since the maximum value for the unmagnetized wires is as high as 1,733 grammes, while the next highest is only 1,728. The objection might be raised that the presence of the iron rod, to which the weights are attached, might be attracted by the coil whenever the wire is magnetized, and thus cause the phenomenon observed by me. To settle this point, experiments were made by substituting a steel yard for the bar A A. The result was that the attraction of the coil on the iron rod was found to be always less than one gramme.

While we may assert, therefore, that the tenacity of soft iron is augmented by magnetization, it is only fair to add that the lack of precise instruments of measurement prevents me from drawing any definite conclusions as to the quantitative relations involved.

It appears, moreover, that the coefficient of elongation also is greater for magnetized than for unmagnetized wires, although three cases out of fourteen gave negative results.

It is with all reserve, therefore, that we may admit the conclusion—obtained also by Baudrimont, "Ann. de Chim. et de Phys." s. iii., t. 30, p. 305, and by Wertheim, s. iii., t. 12, p. 385, namely, that the elongation of metallic wires is proportional to the loads they are made to support until rupture ensues. If, then, magnetized wires are stronger than unmagnetized ones, they are also subjected to the action of heavier weights in our experiments.

If a theoretical explanation should be required, we might account for the increased tenacity of magnetized iron by the polarization of its molecules; opposite poles would then point toward each other, the attraction would be greater, and the effect would be the same as though their cohesion were augmented.

C. F. K.

#### THE RECENT ECLIPSE OF THE SUN.

MR. GEORGE DAVIDSON, of the United States Coast and Geodetic Survey, has made a preliminary report relative to the solar eclipse on January 11, as observed at Santa Lucia, Cal. Santa Lucia was selected as the best point for observations because it was almost exactly on the central line of totality, and because of its elevation above the sea. The instruments, including six telescopes, used by Mr. Davidson and his fellow-observers, were nearly in position, when a violent southwest storm, accompanied by rain, sleet, and snow, and very low temperatures, visited the coast. The storm, however, ceased on the afternoon of January 10. On the 11th, says Mr. Davidson, the day was very clear, the atmosphere steady, the wind moderately strong from the north, and the temperature gradually rising from 15° to about 28°. A low band of clouds about 35° high lay on the ocean horizon all day. Continuing his report, Mr. Davidson says:

The plan of operations was to determine the epochs of the four contacts, to sketch the corona, and to look for Vulcanites. We have observed the four contacts and sketched the corona, the brighter circle concentric with the sun, and the sun flames. Before the first contact the sun's limb was very sharp and steady, with occasional shiverings, but exhibiting no spurious disk, such as would appear from great atmospheric disturbances. The three groups of sun-spots and their peculiarities, and even changes of detail, were constantly well defined. The "rice" mottling of the whole sun's disk was distinctly made out in all the telescopes, and the conformation of the faculae faintly traced. Using a solar eye-piece and high power, I obtained the first contact earlier than the other observers; but it was observed by all. The epoch of observed contact is within a second of time of the prediction. The transit of the moon's disk over the sun-spots was also observed in each telescope. During the progress toward totality I called the observers' attention to the fact that there was a perceptible difference in the darkness of the sky, or background adjacent to the sun's disk, yet unobscured, compared with that immedi-

ately adjacent and covered by the moon's disk projecting beyond the sun's disk. And yet no one of us was able to perceive the moon's disk approaching the sun before first contact.

In watching and studying the sun's cusps, their points were remarkably acute, except at those times when the atmospheric disturbance increased so as to create the slight "shiverings" of the outline or of the spots; then the fire points of the cusps were duplicated apparently at a greater or less distance apart. This was recorded and drawn by Assistant Colonna and myself. With excessive atmospheric disturbance this apparent motion would have increased, and the points would have been seen obtuse and blurred. On the moon's limb, and especially at and near the cusps, the mountains of the moon, projecting beyond its general outline, were plainly visible, and noted as breaking the circular outline of the disk, and similar inequalities could be traced throughout its whole extent. Toward totality, a few cirrus clouds formed in the line of the sun, and the atmospheric disturbance was at times increased.

As totality rapidly approached the crescent of sunlight was remarkably narrow and long, on account of the slight difference of diameters of the sun and moon. The last line of light was from 30° to 40° in length before it broke. But the crescent exhibited no distortion from atmospheric disturbances, and no wavy movement, except occasionally that slight atmospheric disturbance which I have designated as "shivering," and which is seen at times in our geodetic observations. The cusps were remarkably sharp, with curved points, as if cut by the finest graver. The breaking of this extended curved line of sunlight was on account of the lunar inequalities of outline, and presented the appearance of a line of irregular dots, dashes, and spaces. There was no wavy motion to occasion this appearance; whenever one point disappeared it was "gone for good." I did not remove the colored glass in observing this phenomenon (as I had done in 1869 in Alaska), because I wished to preserve my eyes for any possible Vulcanite. But I saw at once that, on account of the contracted diameter of the cone of shade, the illuminated atmosphere all around it rendered the sky too bright for this purpose, and I fixed my attention upon the position and extent of the red flames and the first circle of bright light around the sun, whilst others sketched the corona. There was a brilliant red flame just to the left of the sun's vertex, and the lower part of the moon's disk, say one-third of the sun's circumference, was bordered by a remarkably brilliant and continuous line of red flames. The concentric circle of bright white light around the sun was very striking. Sub-Assistant Dickens noted and sketched a second but fainter concentric circle. The corona had the general form of a parallelogram, with the angles prolonged in the direction of the longer sides, and stretched at an angle of about 30° with the vertical from the upper left to the lower right of the sun. The outlines and general features of the corona are quite consistent among the different sketches, and in addition to the originals I shall have colored a special sketch for my report. Assistants Gilbert and Colonna obtained the third contact, or the ending of totality. The total phase lasted about thirty seconds.

The fourth contact was observed with the sun estimated at about 14° above the horizon, and immediately over the sea bank of clouds. The dip of the horizon was 1° 12' 14". Here the atmosphere was remarkably disturbed and unsteady, and the limbs of the sun and moon moved in great, rapid waves, so that it was next to impossible to note in the smaller telescopes when the moon left the sun. This epoch was observed by myself later than it was by the others, but with no satisfaction, except as being approximately close. The sun set about eleven minutes later. Observations for temperature were made during the progress of the eclipse, and also with the thermometer for solar radiation, which fell from 68° to 28° Fahrenheit at totality.

Jupiter and Mars were seen by the observers several minutes before totality; no stars were seen by any observer. Before totality we all saw the shadow of the eclipse coming over the ocean; and after totality the shade of the cone was observed against the sky over the eastern mountains, but the shadow on the mountains themselves could not be made out on account of the dim light, the sun being on the horizon behind clouds.

This eclipse is another confirmation of the theory that the exhibition of Baily's beads, the ligament and black drop in the transits of Mercury and Venus, the hanging of a colored star on the moon's bright disk at occultation, and similar phenomena, are the consequences of atmospheric disturbances occasioned by irregularities, etc., of refraction. This view has been strongly controverted, but we have analogous phenomena exhibited every day in the geodetic observations of the Coast and Geodetic Survey. At high elevations, and during a remarkably steady atmosphere at any elevation, all these abnormal conditions vanish.

As a spectacle this eclipse in some respect exceeded, and in others was inferior, to that which I observed August 7, 1869, in Alaska. Here the red flames and the inner circle of white light were perfectly glorious, and the corona more brilliant, but the disk of the moon did not stand out with that full blackness and perspective effect which was seen on the Chilkah. The sky at Santa Lucia was much brighter, on account of the relative smallness of the cone of shade. The shadow upon the ocean surface was a poorly defined brown area; in the valley of the Chilkah the coming of the shadow on the mountain flanks and snow-gorges was more distinct and striking.

(Continued from SUPPLEMENT No. 220, page 3494.)

#### ON ACTINOMETERS.

In every experiment the intensity of the electrical current was variable, depending on the thickness of the sensitive compound. With bromide of silver decrease of intensity is more irregular than with the chloride. Iodide of silver, not being blackened by light, gives rise to an electrical current almost as intense as that due to the chloride, but it is not so regular. After many more experiments, M. Becquerel has definitely given to his actinometer the shape represented in the diagram. A glass rectangular vessel, A B, is inclosed in the blackened inside box, M M', having the posterior vertical side provided with a micrometrical apparatus, by means of which a slide can be opened admitting the light to the apparatus. Two metal plates, L L', of pure silver, are suspended by the aid of brass pillars and arms, and are in connection with the galvanometer. The glass vessel is filled with acidulated water to render it a good conductor of electricity, and the plates are covered galvanically with the sensitive substances—chloride, bromide, or iodide of silver. When the desired coating of haloid silver is obtained the plates are heated to a temperature of from 150° to 200° C., till they become of rosy tint. Plate L will prevent the

light striking plate L', but an opaque partition could be used.

This actinometer is very delicate, and it is advisable to have only a very small opening in the side. The light of a candle at the distance of one diameter produces a deviation of 12° to 13°. Very important results were obtained by M. Becquerel when this electro-chemical action on various salts of silver by the rays of different refrangibility was determined. It was found that maximum of action varies with

meter to the colored rays, found that it corresponded with that of the chloride of silver.

**Oxalate of Iron Actinometer.**—This actinometer is based on the principle that ferric oxalate is transformed into ferrous oxalate by the action of light with evolution of carbonic acid gas.

It was Dr. Draper who first observed that solution of ferric oxalate in darkness remains for any length of time unaltered, but as soon as exposed to the action of sunshine

The simplest apparatus for the measurement of actinometer intensity of the light was first introduced by Niepce de St. V. (Fig. 5). It is simply a bottle filled with sensitive liquid, and having the tube, a, passing through the cork, and almost reaching to the bottom of the bottle. The gas evolved by the action of light produces pressure on the surface of the liquid, and, consequently, causes the liquid to rise in the tube. But this simple form is not the best, for the following reason: Carbonic acid produced by the action of light is very soluble in the aqueous solution forming the sensitive liquid; consequently, a large proportion of the gas which is to be used to register the action of light is dissolved in the liquid.

This would not be so very objectionable, if, after this liquid is once saturated, the gas would remain so permanently; but this is not the case. This solubility is widely different at different temperatures—different in the dark and in the light; different at various barometrical pressures. It follows from this that when the newly prepared liquid is exposed to light it does not register the action of light immediately, because a very considerable quantity of gas must be first manufactured for the saturation of the liquid. This is the first error.

Now, suppose we remove the photometer to the dark room, evolution of gas is still going on, because the qua-

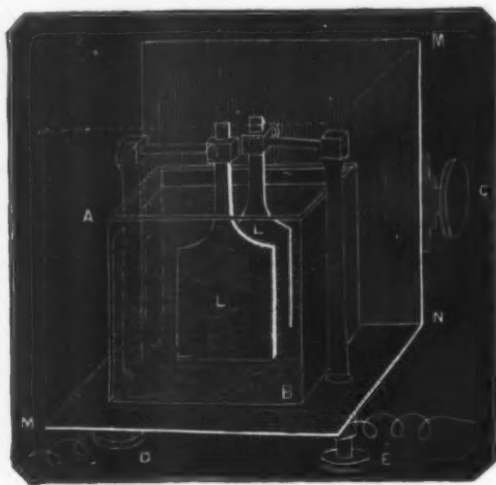


FIG. 3.

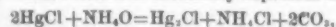
the salt used. When iodide of silver was exposed to light previously it gave two maxima and one minimum, as represented on the diagram. On the diagram the initial letters, A B C, indicate the black lines of the spectrum. The curve, a m H, represents the luminous intensity of the spectrum. A n H, the electric intensity with subchloride of silver. A n d s P, the electric intensity of silver iodide, previously exposed to light. F s P, when iodide of silver was not previously exposed to light.



FIG. 4.

Recently, Mr. Lermantoff, from St. Petersburg University, made an extensive series of interesting experiments with this actinometer; but the result of his very careful investigations, which testify to the correctness of M. Becquerel's results, does not add anything that can recommend this instrument for daily use in the photographic studio, since the manipulations with this instrument are too delicate. By examining the curves of the last diagram it will be evident that the electric intensity under the action of rays of various refrangibility differs from the sensitiveness of the substances generally used in photography.

**Bichloride of Mercury Photometer.**—In the year 1815, M. Becquerel and also Mr. Planche studied the action of light on the mixture of bichloride of mercury and oxalate of ammonia (saturated solutions in equal proportions). This liquid is preserved without change in the dark, but exposed to light it becomes turbid, with a development of carbonic acid. The precipitate formed was found to be proto-chloride of mercury. This reaction is chemically expressed thus:



or bichloride of mercury + ammonia oxalate = protochloride of mercury + chloride of ammonia + carbonic acid.

The action of light can be estimated either by the quantity of the gas evolved or by the quantity of precipitate formed. M. Becquerel employed the last means, and to avoid the evolution of gas he improved the formula, thus:

Water .....	100
Bichloride of mercury .....	6.5
Oxalic acid .....	12.5

In this case, 2HgCl is partly decomposed. Protochloride of mercury is precipitated. The hydrochloric acid liberated forms, with hydrogen of the water, hydrochloric acid. Oxygen, acting on the oxalic acid, transforms it into carbonic acid.

M. Marchand introduced another alteration in the formula—

Water .....	100
Bichloride of mercury .....	6.5
Oxalic acid .....	15.8

The chemical formula will be



This photometer has, however, a very great drawback in the fact that chemical action decreases steadily when it is in action, as can be seen in the following record of experiments: Four identical apparatus were prepared, and the first was exposed from the beginning to the end of the experiment; the others were subsequently introduced:

Hours of Exposure.	Photometers exposed all the time.	Photometers with fresh liquid.
From 10 to 11	0.193	0.566
From 11 to 12	0.172	0.703
From 1 to 2	0.111	0.723
From 2 to 4	0.061	0.554

M. Becquerel, comparing the sensitiveness of this photo-

“actually hisses, through the escape of gas,” which is carbonic acid, whilst a lemon yellow oxalate is precipitated.

This precipitate is the great drawback of these photometers, as the sides of the bottle become covered with it, and the light is thereby obstructed.

Dr. Draper mixed chloride of gold with ferric oxalate, and when exposed to light the ferrous oxalate formed, which caused the precipitation of metallic gold, which could be afterwards weighed. This system is expensive, long, and delicate.

M. Marchand altered the formula, proposing to use a mixture of ferric chloride and oxalic acid almost in equivalent proportions, but with a slight excess of the iron salt. The chemical reaction will be expressed thus:



This liquid is perfectly inert in the dark. It is not congealed even at the temperature of 8° C.

This solution, before exposure to light, can be boiled, without decomposition; but after it is once exposed boiling may occasion what might be a dangerous explosion.

It is very important that the sensitive liquid should remain constantly clear, and this can be attained by strictly following the formula indicated.

Excess of oxalic acid is undesirable, because it helps the production of insoluble ferrous oxalate.

The solution must not be too concentrated, because its action is then not regular.

According to M. Marchand, the following solutions are prepared:

- (1.) Oxalic acid (96.5 per cent. of pure acid). .50 grammes. Water saturated with carbonic acid. . . . . 1 liter.
- (2.) Ferric chloride at 20° B. saturated with carbonic acid.

In one liter bottle is introduced:

Solution No. 1. . . . . 20 c.c.

Solution No. 2. . . . . 10 c.c.

Water saturated with carbonic acid, or old solution, *quant. suff.*

This quantity of solution will act quite uniformly till 200 c.c. of gas is evolved; even then it is far from being exhausted.

For my part I adopt the following formula:

Ferric chloride .....	.60 grammes.
Oxalic acid .....	16.5 “
Water .....	60 c.c.

I did not saturate it previously with carbonic acid, but began my observations after the apparatus had been exposed



FIG. 5.

for some time to the action of light, and when, consequently, the mixture is self-saturated with carbonic acid. As to the amount of gas evolved, I followed the limits indicated by M. Marchand.\*

\* Etude sur la Force Chimique de la Lumiere du Soleil.

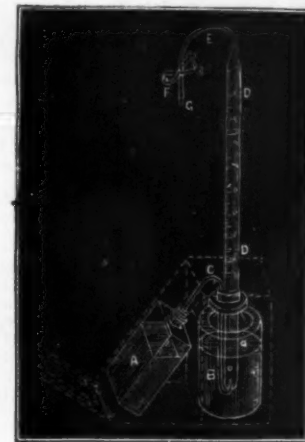


FIG. 6.

A is a flat glass bottle containing the sensitive liquid.

B is another bottle filled with glycerine.

C is a glass tube conducting the gases from the generator, A, to the bottle, B.

D is a graduated glass tube.

E is an India-rubber tube with clip, F, inserted in the bottle, B.

ity dissolved in the liquid during the exposure cannot be contained by it in the dark, the solubility being lessened. To this must be added other causes besides difference of temperature. I can compare this action to the following illustration: Suppose a sponge, which we may compare to the sensitive liquid. Let us pass a stream of water from the tap on the sponge; this is the light. Next, suppose we put a graduated measure under the sponge in order to ascertain the amount of water coming from the tap. Naturally it will take some time after the tap is turned on before any water will come into the glass measure, because the sponge will absorb it. Likewise, when we stop the water from the tap it will still ooze from the sponge. If we squeeze the sponge, or by any other means alter the equilibrium of the sponge, some additional water will flow. Exactly the same happens with this actinometer. The larger the sponge, or the greater is the amount of sensitive aqueous liquid, the greater will be the errors arising. This consideration decided me to separate the motive part of the apparatus from the registering, and this form I successfully used for a period of eight years.

By sucking the air through the glass, G, the glycerine can be raised to the zero point on the graduated tube, D. The gas produced in the generator, A, will pass in bubbles to the tube, D, displacing the glycerine, and the graduation of the tube will give the volume of gas. The reason glycerine is used in this apparatus is that this liquid dissolves less carbonic acid than any other.

The following is a very interesting result obtained by M. Marchand in regard to this. Carbonic acid gas was collected over glycerine in the glass receiver:

On the 1st day there was 74 c.c. of gas.

2d	73
3d	73.5
4th	74.1
5th	73.4
6th	72.9
7th	72
8th	72.4
9th	72.4

On other occasions 372.4 c.c. of carbonic acid, and 290.3 of air, was kept in two separate receivers over glycerine for over five months, and after this time, the volume of gas was found to be 259.6, and of air 278.4, showing clearly that glycerine absorbs a comparatively small quantity of gas or of air.

To form a more exact comparison, I may here state that one hundred volumes of water dissolve about one hundred volumes of carbonic acid at the temperature of this room (15° Cent.), and 175 at freezing point.

It is also interesting to note the absorptive power of the sensitive liquid, and the following is the result:

Through the solution of oxalic acid all the colored rays pass.

Through the solution of ferric chloride, the red, orange, yellow, green, and very little blue pass.

Through the sensitive mixture (as indicated) only red, orange, yellow, and green, but not a trace of blue, pass.

In the form just described, this actinometer is very valuable for registering the accumulative action of light in all the processes requiring long exposure. I found it especially in connection with the asphalt process. The exposure required in this case in this season is sometimes as long as six days; and numerous experiments satisfied me as to the incalculable value and correctness of this actinometer. In

the model shown to you the diameter of the graduated tube is rather large. For processes requiring less exposure—for instance, for carbon printing—a small diameter is used. When still shorter exposure is to be registered, I could pretty correctly judge of the intensity of light by the number of bubbles of gas that can be observed at the one time ascending the length of tube, or, in other words, the frequency of the bubbles.

In order, however, to estimate more correctly the actinic action of the light an apparatus was constructed (Fig. 8), consisting of flattened long bottles filled with sensitive liquid. This bottle has a perforated stopper, as also the neck of the bottle, and in such a manner that, when it is put in one

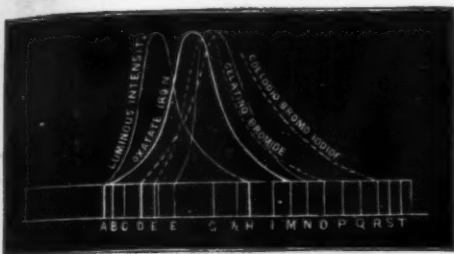


FIG. 7.

Note.—The middle continuous curve shows the action of light on chloride of silver paper.

position as shown, the gas produced by the action of light will escape in the air. On the opposite side of the neck there is a long horizontal tube of small diameter, having at the other end two branching tubes; on the extreme branch

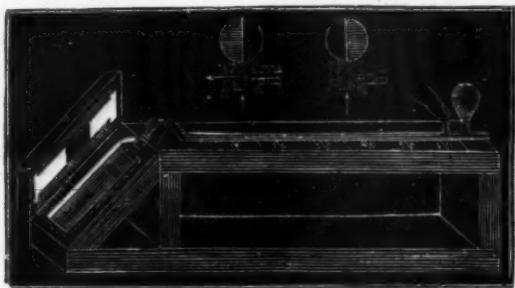


FIG. 8.

is placed an India-rubber ball, while the other remains open. Through this last branch tube is introduced a drop of mercury, and, after the orifice is closed with a finger, the India-rubber ball is gently pressed, which occasions a movement of the drop of mercury, and when it occupies the position corresponding to the *o* of the scale the finger is removed. Now, when exposure is to begin, the glass stopper is turned so as to occupy the second position shown; the gas then penetrating into the long tube will produce the pressure, and consequent movement of the mercury. The attached scale will register the amount of gas.

The aperture through which the light acts on the sensitive liquid can be altered according to necessity, by an arrangement applicable to all other forms of this instrument.

In the course of my experiments it necessarily occurred to me to introduce an alarm, informing the operator of the exact moment when the amount of light was sufficient to produce the required action.

The apparatus constructed by me for the purpose (see Fig. 9), was formed of a flat bottle as before, to hold the sensitive liquid. The glass tube, of the shape of the letter U,



FIG. 9.

was used as a receptacle for the glycerine. One end of this tube was connected with the flat bottle, while through the other end was introduced a cork float carrying a light platinum wire. When gas, produced by the action of light, begins to press on the surface of glycerine in the U tube, the surface of it begins to rise in the other branch, the float is raised till it touches the small adjustable metallic ball forming the part of arrangement which is sufficiently intelligible from the examination of the diagram. On the top is fixed an ordinary electric alarm bell, which as soon as the connection is effected, calls the attention of the operator to the fact that the requisite amount of light has been acting. In the diagram, for simplicity's sake, the battery is not represented; but it consists of a small Leclanche cell.

LEON WARNERKE.

[Continued from SUPPLEMENT, No. 214, page 3410.]  
**PROGRESS OF INDUSTRIAL CHEMISTRY.**  
 (American Chemical Journal.)

**BRIEF REVIEW OF THE MOST IMPORTANT CHANGES IN THE INDUSTRIAL APPLICATIONS OF CHEMISTRY WITHIN THE LAST FEW YEARS.**

By J. W. MALLETT.

**Calcium acid phosphate.**—The immense extension which the trade in "super-phosphate of lime" has taken of late years has led to many small improvements in the mechanical appliances of the manufacture, and some small changes in the chemical treatment used, so as to adapt it to the various phosphatic materials brought into the market, but no change of general importance has been made.

**Aluminum sulphate.**—This salt, though always open to the objection of variability of constitution as it reaches the market, has been made of better quality of late than in former years, more nearly definite in character, and freer from iron. Especially is this true of the so-called "porous alum" made from kryolite. Under the name "alum clay cake," that made from clay and still retaining silica in admixture with it finds extensive use among paper makers and for some of the less refined processes of dyeing, and is manufactured upon an increasing scale, both for such direct use and for conversion into alum.

**Alum.**—The working of alum shale and alum earth, though still practiced upon a very large scale, has of late years been relatively falling behind, some large establishments having even been abandoned, while clay, bauxite, and kryolite have assumed increased importance as sources of the aluminum required, sodium aluminate being first made from the two latter, partly used as such and partly converted into alum. In working shale, moreover, sulphuric acid is largely used now, instead of depending upon the oxidation of the disseminated pyrites.

As regards the alkaline sulphate used in making the double salt, the tendency for a number of years has been

hardly believe that new and important uses will not yet be found for this potent reagent, now mainly devoted to the production of potassium bromide, the employment of which in medicine upon a very large scale is the result of but a few years' experience. The substitution of bromine for iodine alcoholic compounds in the manufacture of the coal-tar dyes was at one time eagerly attempted, then pronounced unsatisfactory, but has again, in modified form, come to some extent into use, while bromine derivatives of the hydrocarbons and phenols have played some part in the development of other branches of the industry of artificial dyestuffs, especially of late in the production of eosine and other resorcin derivatives. It seems really desirable that a careful test shall be made of the economy with which bromine may be substituted for chlorine in the application of Plattner's process, simplified, to saving gold from the "tailings" and "beach-sands" of the Pacific States. It does not appear impossible that such an application might be combined with arrangements for recovering at least the greater part of the bromine; but, even without this, there are probably localities at which the method might be profitably used.

There is little new in the comparatively simple processes by which bromine is at present made. Some ingenuity has been shown, however, in devising the means for avoiding danger and annoyance in the transportation of so active and volatile a substance; for example, it has been shipped, when not at once made into potassium bromide, as bromide of iron, and of ethyl, in harmless solid and liquid form.

**Phosphorus.**—In view of the small reason for making, at the present day, any special mystery of this manufacture, it is a little remarkable how difficult it is to obtain accurate information as to its details; probably the chief cause of this is the concentration of the manufacture in the hands of a very few firms. It is said that mineral phosphates, the so-called coprolites, Redonda guano, etc., have largely, if not for the most part, replaced bone-ash as the crude material used. It is reported, too, that instead of limiting the action upon this of sulphuric acid to the removal of two-thirds only of the calcium, all is removed as calcium sulphate, and sirupy phosphoric acid, dried up with charcoal powder, constitutes the material submitted to distillation. The suggestion made long ago by Wöhler, to dispense altogether with the use of sulphuric acid, and procure phosphorus by distilling a mixture of calcium phosphate, silica, and carbon, is said to have been adopted upon an industrial scale some years since in France, but whether successfully and persistently may be doubted—the very high temperature necessary for fairly complete decomposition of the phosphate is a serious drawback. The failure of amorphous phosphorus to replace the ordinary variety in the manufacture of all friction matches has not arrested the production of the former on the large scale. In making matches the much more ready inflammability of common phosphorus causes it to be most extensively employed, but use is made of the amorphous form of the element to some extent for matches and for the surfaces upon which "safety matches" are ignited, as well as under circumstances which make its more manageable chemical activity advantageous, as in making the haloid compounds of ethyl and methyl for the production of the aniline dyes. A new field for the use of phosphorus in metallurgy has been opened up by the introduction of phosphor-bronze, already referred to in this report.

**Carbon disulphide.**—This substance, possessing special value as a solvent, has been an article of manufacture in a large way for but a moderate number of years. The scale upon which it is made has rapidly increased, but has been hardly kept pace with by improvement in the method used and in economy of result. Iron retorts have been substituted for those of clay formerly in use, and the practice has been introduced of distilling over the sulphur and bringing it into the retort in the form of vapor to act upon the red-hot carbon. The iron of the retorts is attacked and gradually converted into sulphide; although the walls are made thick enough to last for a considerable time, it seems likely that additional durability might be gained by washing over the inside surface with a moderately fusible glaze, as of borax and clay. The product is refined with much greater care than formerly, so that much of that to be found in commerce is almost quite free from the very nauseous odor belonging to the crude liquid first condensed. A large amount of free sulphur being carried over with the sulphide, having afterward to be separated in the refining process, it would seem well to transmit the mixed vapors from the first retort through a second, or even a third, cylinder of glowing carbon before carrying them off to the condensing apparatus.

Used at first almost solely by the manufacturers of India-rubber, carbon disulphide has acquired greatly increased importance as furnishing the means of dissolving out fats and oils from various materials which could not be treated with equal advantage in any other way. Thus from oil-seed cakes, from the marc of olive oil pressing, from woolen rags and waste, from cotton waste used in wiping machinery and packing stuffing-boxes and axles, and from bones from which gelatine and phosphates are afterwards to be made, large quantities of fat are recovered. To a limited extent the same solvent has been brought into use to collect sulphur from poor "sulphur-stone," and to extract delicate perfumes and the aromatic ingredients of spices and condiments. For all these purposes a rival has appeared in the shape of the more volatile portions of petroleum, forming the so-called petroleum spirit or petroleum naphtha. The abundant supply of this at a very cheap rate has tended for a few years past to check the extension of the carbon disulphide manufacture. A new and special use for the latter has, however, quite lately grown up in its application as such, as well as the sulpho-carbonates, as the means of checking the ravages of the phylloxera in European, especially French, vineyards. Later the ethyl and amyl-disulphocarbonates have come into use for this purpose.

Potassium amyl-disulphocarbonate is said to have proved cheapest and most easily prepared by simply bringing together, with precautions against too great rise of temperature, a strong solution of potassium hydrate, amyl alcohol of fusel oil, and carbon disulphide.

**Arsenic acid.**—has come to be largely manufactured to be used in the conversion of commercial aniline oil into fuchsine, common arsenious oxide being treated with boiling nitric acid, or dissolved in hot hydrochloric acid and submitted to the action of a stream of gaseous chlorine. The recovery and utilization of the arsenic from the residues of fuchsine production has been attempted in various ways, none of them quite satisfactory on both economic and sanitary grounds. Sodium arseniate constitutes a large portion of the "dung substitute" used by calico-printers in developing sharp, well-defined patterns with clear grounds, and has come to be made on a pretty large scale by treating arsen-

toward the substitution of potassium by ammonium sulphate, but this has to some extent been checked, particularly in Germany, by the abundant supplies of potassium compounds from Staßfurt.

**Iron (ferrous) and copper sulphates.**—Nothing of special importance as to these heavy metal salts requires notice, except that an extension has been given to the material for their manufacture as secondary products of metallurgical operations, in the growing production of "cementation" copper in the wet way, and in the extraction of gold and silver from copper regulus or copper mattes employed as the means of concentrating the precious metals.

**MINOR CHEMICAL MANUFACTURES.—INORGANIC CHEMICALS.**

**Iodine.**—The chief event in the recent history of iodine production has been the utilization of the mother-liquors from which Chilian sodium nitrate has been crystallized. Cupric sulphate and sodium sulphite being added to the liquid, cuprous iodide is precipitated, and this, for the most part shipped to Europe, is afterward decomposed by sulphureted hydrogen or by zinc, and converted into an alkaline iodide; to a less extent the solutions are treated with a regulated quantity of sodium sulphite alone, and the iodine collected as such either by precipitation or distillation. Kelp has until lately remained the most important source of supply, although this material is worked at a serious disadvantage since its potassium and sodium salts have had to bear in the market the competition of the products of Staßfurt industry and the greatly extended Leblanc process. Large loss of iodine is known to occur in burning to kelp the seaweeds exposed to atmospheric oxygen, but the attempt to remedy this by charring in close vessels instead of burning, utilizing afterward the volatile products, seems to have failed of success from the unwieldy mass of crude seaweed requiring transportation to the seat of such manufacture. The rapid increase of demand, and consequently of price, for iodine, caused by its extensive use in making sundry of the coal-tar colors, notably the violets and greens, has been followed by a partial falling off, due to the efforts to substitute in this application other salts for the iodides of the alcohol radicals. The problem of finding means, physical or chemical, for obtaining directly from sea water the minute amount of iodine it contains, seems still perhaps worthy of consideration.

**Potassium iodide.**—The medicinal use of this salt continually increases the scale upon which its production is required, while the statistics of photography show a still more rapid increase of the demand for it wherever civilized man is to be found. A recent paper by E. Schering discusses the different methods employed for making it, of which on the whole that which seems most generally in use is the solution of iodine in aqueous potassium hydrate, evaporation to dryness with addition of charcoal powder, and ignition to destroy the iodate formed; Schering himself, however, giving the preference to the production of iron iodide and decomposition by potassium carbonate.

**Bromine.**—It is but a short time since this was but a rare laboratory chemical; now it is manufactured by tens, nay hundreds of thousands of pounds annually, and its production upon a still larger scale is prevented merely by the low price which it commands at present. Formerly obtained only from the "bittern" of sea-water evaporation, and in a very small way from kelp, the two new sources of supply which have proved so much more extensively available are the mother-liquors obtained at Staßfurt in working the salts of potassium and magnesium, and those produced in salt-boiling in Ohio, West Virginia, and Pennsylvania. One can

ious oxide with strong soda-lye, evaporating and fusing the residue with sodium nitrate.

**Oxygen gas.**—The nearest approach to a process fit for successful technical use in making gaseous oxygen upon a large scale is undoubtedly that of Tessié du Motay, consisting in exposing sodium manganate at a low red heat to a current of superheated steam, reproducing the manganate from the residue of manganese sesquioxide and sodium hydrate by passing purified air over it at the same temperature. The cost of the gas is still far from having been reduced to the point at which it might be, with great advantage, used for many industrial purposes, notably in the manufacture of sulphuric acid in closed chambers; but the gas may be said to have acquired a certain commercial foothold, and its application in some directions has been facilitated by the system of storing it under a pressure of several atmospheres in portable iron cylinders. In giving control of a temperature at which platinum and iridium may be melted into large ingots, in affording the means of producing light of an intensity comparable with that more commonly now derived from an electric current, and under conditions sometimes more conveniently available than the latter, and in its medicinal application the gas has already rendered useful service. Under this last head the notices in some scientific works and reports of late years have tended to give an unduly depreciated idea of the therapeutic value of the substance. While the old notion of the respiration of pure oxygen having any *chemical* value is of course no longer entertained, the relief which may be afforded a patient in the advanced stages of phthisis, in pneumonia and any other affection interfering in a purely mechanical way with the volume of air with which the lungs can be effectively supplied, if once witnessed, will not be underrated or denied.

The preparation and sale, in similar compressed form, of nitrogen monoxide for dentists' use, and of hydrogen for employment with oxygen in the production of the "calcium light," have become common, though upon no very great scale. For making hydrogen industrially the plan of Tessié du Motay is worth notice—namely, heating surplus carbon with slacked lime, giving rise to the reaction  $\text{Ca}(\text{HO})_2 + \text{H}_2\text{O} + \text{C} = \text{CaCO}_3 + 2\text{H}_2$ , and reproducing calcium hydrate by passing steam over the heated carbonate which has been formed. Save for a few special purposes, as occasionally for filling balloons so as to give them unusual ascensive power, it seems unlikely that the place of pure hydrogen in industrial applications cannot be equally well or better taken by the gaseous mixture which contains it along with carbon monoxide, nitrogen, etc., known as "water gas" or "generator gas."

Many other substances might be named which have gradually been passing, under the eyes of those still of the present generation, from the domain of the scientific or the pharmaceutical laboratory into that of the manufacturing chemist. There seems no reason to doubt that *ozone* has for some time been more or less experimentally used in bleaching sugar, while hydrogen dioxide has been brought into the market as the "Eau de la Fontaine de Jouvence" for partially destroying the color of human hair, pending any serious use of it in bleaching textile fabrics. *Nitrous acid* and *nitrites* have taken rank among the regular working reagents of the maker of coal-tar colors. *Silver nitrite* is made by tons for the purposes of the photographer, as well as for medical and surgical use. The *double salts of ammonium with nickel or cobalt* are consumed in great quantity by the electro-plater, while salts of such rare metals as *vanadium* and *cerium* are regularly applied in the processes of calico-printing.

#### ORGANIC CHEMICALS.

In the production of these much greater changes have occurred, and much greater advances have been made within but few years than has been the case in regard to inorganic materials. Most of the substances in question, however, find their application in connection with particular arts, and are better considered in relation to these. A few may be noted here.

**Methyl alcohol** has long been used as a solvent, but more largely than ever with the progress of manufacturing organic chemistry, and under the influence of revenue laws permitting ordinary alcohol, when mixed with this wood spirit, to be used without heavy taxation. In the coal-tar color industry, moreover, methyl alcohol itself and several of its derivatives play an important part. For the production of the methyl acid derivatives of rosaniline, etc.

**Methyl chloride** has taken the place of the dangerous methyl nitrate, and to some extent of the more expensive iodide, without, however, displacing altogether the latter, and has also been brought into use as one of the materials for the production of artificial cold by rapid evaporation in closed vessels.

**Ethyl alcohol** up to almost "absolute" strength and well freed from foreign alcoholic and other impurities, can now be had in commerce, distilled in apparatus capable of more rapid and delicate fractional separation of the distillates than was industrially common not long ago. Amongst the more extensively prepared products from ordinary alcohol.

**Ether and chloroform** are made chiefly by processes long in use, and which have undergone no important modification of late (chloroform is made to a small extent from chloral hydrate), but greater pains are taken with the final purification, sometimes now carried out by other hands than those which have turned out the crude product, and a much higher and more uniform standard of purity has consequently been attained by the best makers for medical and surgical use.

**Chloral hydrate** has taken its well-recognized place among therapeutic agents and become an article of regular manufacture upon a very large scale. In a much smaller way *iodoform* has also entered the field of industrial production.

**Ethyl iodide and bromide** enter largely into the resources of the coal-tar color maker, and the latter, as above noticed, has been made the means of safely transporting bromine, to be afterwards recovered in the free state, if desired, with regeneration of ordinary alcohol.

**Amyl alcohol** has ceased to be regarded solely as a mischievous impurity of distilled spirits, and has, with some of the compounds obtainable from it, come to find useful applications. Amylated derivatives of rosaniline and allied color bases are made from the iodide, bromide, and chloride, while *amyl nitrite* and *valerianic acid*, with its salts, have become common products for medical use.

Few substances have acquired more widely extended importance than *glycerine*, both on account of its special or individual properties and those which, in modified form, it shares with bodies earlier known and used. Its history, however, rather belongs with that of the fats from which it is derived.

The manufacture of *phenol* or *carbolic acid* has developed

a distinct branch of the many-sided industry of coal-tar, and in beautifully pure, colorless, crystalline form replaces the coarse, dark-brown "coal-tar creosote" which alone was known but a few years ago.

**Cresol and thymol** have also become regular articles of manufacture.

**Benzoic acid** is said to be still made to some extent from benzoïn, or perhaps partly from Australian "acacoid resin" (of *Xanthorrhoea hastilis*), but it is mainly and largely obtained by evaporating the urine of herbivorous domestic animals and boiling with hydrochloric acid to decompose the hippuric acid present. Some is also produced in France, by Poirrier and others, by continuous boiling of benzyl chloride with strong nitric acid. The conversion of naphthalene into phthalic acid, and this into benzoic, seems to have proved on the large scale less advantageous. Besides the consumption of benzoic acid in making the artificial colors for dyers' use, there is reason to believe that it enters to some extent into the composition of the secret nostrums used in flavoring manufactured tobacco.

**Sulilic acid** may more properly be considered in its special relations among antiseptics. Its synthetic production by Kolbe's process from phenol sodium and carbon dioxide represents one of the most admirable gifts of pure chemistry in modern times to medical, sanitary, and industrial progress.

**Phthalic acid** is another of the products called for by the maker of artificial chemical dyestuffs. The use of its anhydride in the development of eosine and the other beautifully colored derivatives of Baeyer's phthalicins has led to its being itself largely made from the naphthalene which was so long associated almost solely in chemists' minds with the classical "light-bearing" researches of Laurent.

In connection with the same great field of the last twenty years' work upon the colored products obtainable from tar, innumerable chlorinated and brominated derivatives of hydrocarbons, phenols, acids, have been made upon a larger or smaller scale; and of late still more extensively organosulphonic acids, but for the most part these have not formed the final products of separate chemical manufactures, but have constituted single steps in the work of the producers of the dyestuffs themselves.

In regard to the treatment of the *natural vegetable alkaloids* recent times have not been without their evidences of progress. Attention has been given to improving, both in quantity and quality, the supply of original material, notably in the direction of cinchona cultivation under Dutch and English auspices in Java and Southern India, and in connection with such efforts chemistry has aided in some measure as a guide to practice. The scale upon which *quinine*, *morphine*, *strychnine*, and *atropine*, were formerly made has undergone very great extension, and although no radical change has probably been made in the processes by which these alkaloids are extracted, the final purification has been much improved, especially as to the more easily alterable bases, and new solvents have served to cheapen the processes and facilitate crystallization. The other cinchona alkaloids which accompany quinine have, either singly or in admixture been brought to some extent into use instead of merely accumulating them as worthless by-products. Some new substances of this class have been made available for medical purposes and are added to the list of those manufactured, as for example, the *eserine* of Calabar bean; while among the products of chemical alteration *apomorphine* has been found valuable. Researches of a purely scientific character upon the less known substances classed as vegetable alkaloids, but turning out to be in some cases complex mixtures, as *aconitine* and *veratrine* promise to yield results before long of practical applicability.

#### MECHANICAL APPLICATIONS OF CHEMICAL MANUFACTURES IN GENERAL.

Among the chief directions of improvement in the "plant," appliances, and physical methods of working of chemical factories may be noted:

**Improved grinding mills**, especially those run at comparatively high speed and aiming at true grinding rather than crushing.

The extended use of *steam coils* and *steam jackets* for heating purposes, admitting of complete control and nice regulation of temperature.

**Heating by vapor from materials under treatment**, such an adjustment being made of the different portions of the work as to permit of this utilization of otherwise waste heat, and sometimes allowing of simplification in the working itself.

**Heating under pressure** greater than that of the atmosphere, the use of so-called "autoclaves," often arranged with special ingenuity as to the details of filling, emptying, observing the progress of reactions occurring within, etc., playing an important part in some of the branches of modern chemical industry.

The use of "ice machines" for the production of artificial cold. These valuable machines have lent most important aid in various directions, enabling results of solidification, crystallization, rapid cooling to determinate temperatures, etc., to be secured in climates and seasons, and under temporary conditions of weather which would otherwise prove serious if not insuperable obstacles. In many cases uniformity of working is gained by the control thus given of temperature in the downward as formerly in the upward direction. In turn, manufacturing chemistry has been called upon to supply the materials used in most of these machines to produce cold by evaporation, as ethyl and methyl ethers, methyl chloride, petroleum spirit (mainly butane), ammonia and sulphur dioxide, the machine working with air alternately compressed and expanded alone using a material furnished by nature.

**Improved mechanical arrangements for agitation or stirring of liquids**, including under this head not only revolving paddle arms and the like contrivances, but the blowing in of air or steam, often now made to accomplish the work of stirring and mixing, and at the same time that of heating, oxidation, etc.

Extended use of *vacuum pans* for evaporation, with or without arrangements for condensing the vapor given off. The vacuum pan has long ceased to be a part only of the special plant of the sugar refinery, and has become one of the well recognized appliances of the general manufacturing chemist, without which much of the treatment of the more delicate and easily alterable materials he has to deal with could with difficulty be accomplished.

**Improved apparatus for distillation**, especially that intended to effect nice fractional separation of liquids differing often but little in boiling point. The extension upon a manufacturing scale of the processes of organic chemistry has given to this increased importance.

Introduction of the method of *distillation by means of or along with super-heated steam*. In certain cases this enables

a simple physical purification of special materials to be effected which otherwise would require elaborate and tedious chemical processes to be used.

The general application of "*centrifugal machines*" or "*hydro-extractors*" for draining and washing suitably divided solid materials, especially crystals. The quickness and thoroughness with which the work is done, and the limited amount of wash water or other fluid necessary, constitute important advantages.

The use of *filters arranged to work with a partial vacuum*, so as to expedite filtration and leave the solid residue in a more effectually drained condition.

The use of *filter presses* to mechanically squeeze out the liquid tenaciously retained by precipitates, sediments, sludges, etc. These have been much improved of late by the general substitution of metal for wood in their construction, the increased pressure obtainable—commonly up to 150 or 180 lb. per square inch—the rapidity with which the pressure is brought to bear and the readiness with which it may be regulated, the thoroughness with which a small quantity of washing fluid may be made to remove residual soluble matter, and the substantial and durable character given to the framework and mechanism. In a multitude of cases chemical industry has derived most valuable aid from these useful pieces of mechanism in their more modern forms.

#### FLINT OR CRYSTAL GLASS.

**FLINT glass** is a bisilicate of potash and lead, with a supercharge of silicic acid, which was absorbed by the two silicates at a high temperature. Although it is considered as insoluble, this assumption is not sustained by the facts: for if pulverized flint glass is boiled in distilled water, a considerable portion will dissolve.

Faraday found, by analysis, the following composition:

Silicic acid.....	52
Oxide of alkali.....	14
Oxide of lead.....	38
	99

Of course, the proportions thus found are not always the same as had been mixed before melting; for the alkali had been added as carbonate of alkali, *i. e.*  $\text{CO}_2\text{OR}$ , instead of  $\text{OR}$ , but as  $(\text{CO}_2=44) \times (\text{OR}=94)=138$ , we ought to have the ratio 94 : 138 :: 14 : 20.7, making 14 oxide of alkali equal to 20.5 carbonate of alkali. But, as  $52 \times 20.5 \times 33=105.5$ , and not 99, the proportion of composition would be as follows:

Silicic acid.....	49.28
Carbonate of alkali.....	19.48
Oxide of lead.....	31.27
	99.21

In practice, the formula of 1 part of potash, 2 parts of oxide of lead, 3 parts of sand, is universally adopted as normal, making the quantities as follows:

Potash.....	17
Oxide of lead.....	33
Sand.....	50
	100

This latter composition differs but little from the result of the analysis, but would be less soluble. If sand could be found quite free from iron, such a mixture would produce a perfectly faultless, colorless glass; for the other ingredients can be artificially produced in almost perfect chemical purity. But, as we know, sand is never found without ferruginous matter, and even small traces of it suffice to give the glass a greenish hue. For the manufacture of perfectly pure silicic acid, a treatment with muriatic and sulphuric acid, and a subsequent careful washing would be required, making the manufacture of flint glass essentially dearer. The coloring property of the ferruginous parts of sand, however, can be neutralized in a less costly way. Iron only colors glass green when it appears as a protoxide of iron, while the higher grades of oxide are incapable of imparting any hue. Now, if we discover a process by which the protoxide can be changed into an oxide, the coloring property would disappear.

To secure this result, we add a small portion of saltpeter, or superoxide of manganese, to the mixture. In most instances an ounce is sufficient. The superoxide of manganese colors the glass amethyst, while the oxide of manganese leaves it perfectly colorless; consequently the oxides of iron stand to the oxides of manganese in the relation of chromatic antidotes. The lower oxides of iron color glass, the higher do not; the lower grades of manganese do not dye glass, the higher do.

When iron is contained in the mixture, in melting it will, undoubtedly, be changed into protoxide, and impart a greenish hue to the glass; now, if we add superoxide of manganese, it would color the glass amethyst, and thus hide the green; but at a melting temperature one atom of oxygen is forced away from the superoxide of manganese, changing it at once into oxide of manganese. The oxygen thus freed is absorbed by the protoxide of iron, changing it into oxide of iron. In this way the heat causes the two oxides to form colorless glass. To make this process successful, we must know the exact relation of the two oxides to one another.

Now, if the contents of iron in sand were the only causes of impurity in glass, they would give us proportionately little trouble, because the correct quantity of the manganese to be added, having once been determined, we could, without difficulty, regulate the color, as long as we use the same sand. This process is, in fact, applied to the manufacture of the best quality of flint glass, known under the name of "best metal," which is always melted from a fresh and pure mixture; but the case lies different with the lower grades of the flint glass, which must be just as free from color as the best sort. For the lower grades we use all the waste of the "best metal," as well as the breakage of the same, and the glass which gathers at the blow-pipe, and, of course, becomes more or less ferruginous by its contact with the pipe. This matter receives the technical name of "black," and its discoloration requires particular attention. This stuff, called "cullet," embraced, originally, only the waste resulting from the fabrication, but was soon extended to all broken glass, forming the vexation of the glass-blower, known as "black beast." In this broken glass he has glass of the most different compositions, and, of course, densities, making it difficult to melt the various sorts to homogeneous mass. In working, the mass thus obtained will mostly form refuse, and force us to dip out the mass and melt it over with fresh material.

In melting, we often use the trick of adding ingredients quickening the fusion of the mass. Some apply borax, but a mixture of potash, sand, and oxide of lead is more gener-

ally used. Soda, however, imparts to the glass a yellowish hue, which must be removed by the admixture of ether, a small dose of arsenite of lead, or a piece of white arsenic, forming arsenious acid with the oxide of lead contained in the mass. This arsenite of lead is of a milky color, neutralizing the yellow hue of the soda, and promoting, moreover, the fusion of the silicic acid.

Although, as seen from the above remarks, the melting of glass is a chemical process, the success of the operation depends also much upon the empiric manipulation and experience of the manufacturer of glass. Chemical knowledge, however, is of the utmost importance to him, as, in fact, to all other followers of industrial pursuits. It enables him to examine the quality and purity of his materials, and the production of a colorless and brilliant flint glass depends much upon the excellence of his potash and red lead, and the purity of his sand, although the quality of the other ingredients, such as saltpeter, manganese, borax, and arsenic, is also important, since they can impart impurities to the glass. Having chosen his raw materials with the sagacity of an expert, the manufacturer will be able to produce crystal glass of the purest water, only surpassed by the diamond, and frequently used to imitate this precious stone.

But the selection of the raw material is not the only requirement for the production of a faultless article; the greatest attention must also be paid to the process of melting. After the ingredients have been weighed and carefully mixed, the mass is placed into the pots, not all at once, but rather in four divisions, each of which must first be in perfect fusion before the next is introduced. When the crucible has been filled to its mouth, it is placed in a furnace and abandoned to a slow fusion, at a temperature of 2,500° Fahrenheit, which will be perfected in about four hours. The furnace assumes a light yellow, almost white heat. After the mixture has become perfectly fused, the contents of the pot are poured, by means of great ladles, into a kettle of cold water constantly running. This process renders the glass brittle, allowing it to be reduced to small pieces, and to be mixed with new matter. To this mixture is now also added the amount of manganese required for neutralization, whereupon the crucible is once more charged as before, and then covered with two layers of fire bricks, the joints being plastered up with clay. To avoid a useless waste of heat, the working holes are closed with iron doors, and then the mass abandoned to a slow fusion and purification, which, with a pot containing about eighteen hundred weight, is accomplished in about thirty-six hours. Great care must be taken that the temperature of the furnace is, from the start, an uninterruptedly uniform one, because otherwise the rising glass bubbles cannot properly escape, but will subdivide into innumerable bubbles of diminutive size, which remain in the mass, and can never be removed by a subsequent heat, no matter how great the same may be. In such a case, there is no remedy but dipping out and melting over with additional matter. The temperature must neither be too high nor too low. If too high, it often happens that the reduction of the superoxide of manganese is brought about, without the union of the liberated oxygen with the protoxide of iron, leaving the glass green, and consequently, worthless.

After the above described manipulations have been carefully carried out, and the contents of the crucibles properly purified—which state the melter can ascertain by inserting an iron rod through a small aperture into the mass and drawing forth a sample—the pot is uncovered, the surface of the glass skimmed, in order to remove all impurities swimming on the surface, and finally scraped. This is done by lifting a small portion of the melted glass with the blowing tool, and by cooling and rolling the same into a broad scraper, which is passed over the surface, in order to remove a thin coat of the melted glass, in which casual impurities, such as dust, or particles of burnt clay, may have remained.

The glass is now ready for being worked into the most manifold articles. Skipping this mere mechanical labor, we pass, finally, to the process of annealing. Although this process affects, principally, the physical properties of the glass, chemical combinations also take place during its continuation. If, for instance, more manganese had been added than the protoxide of iron was capable of absorbing, an excess of superoxide of manganese will remain, causing a violet hue of the glass. If this hue is not too intense, it may yet be removed in the annealing oven. In such a case, the article to be annealed is then allowed to remain for a longer time in the hotter part of the oven, and only slowly shoved to the cooler end, thus producing a dioxidation of the superoxide of manganese. This closes the chemical process in the manufacture of flint glass, the most beautiful, transparent, and brilliant of all glasses, owing its great power of refraction to the oxide of lead. It is, indeed, not so hard as the lime and barytes glass, but infinitely more useful in the manufacture of articles of luxury, as well as common-use.

#### CUPRIC TEST-PELLETS FOR SUGAR.

At a recent meeting of the Clinical Society, London, Dr. Pavy said that he desired to introduce to the notice of the members a new form of test for sugar, which he thought would prove of no inconsiderable service to the medical practitioners. Of the various reagents that have been recommended for the detection of sugar, his experience led him to consider the cupric test by far the most reliable, and this view stood in accord with that which was generally entertained by analytical chemists. It had been hitherto the practice, certainly where delicacy and precision were in question, to employ the test in the form of a solution prepared by mixing an alkaline tartrate with sulphate of copper and either potash or soda. Such a solution contains the oxide of copper in a state ready to be reduced to the condition of the suboxide when in contact at a boiling temperature with glucose. When freshly prepared this solution fulfills all that can be desired, but there is the disadvantage belonging to it that after being kept for some time, especially if exposed to light and air, it is liable, without the presence of sugar, to throw down a certain amount of reduced oxide on boiling, and thus possibly to mislead unless precautions are taken to provide against it. Besides this objection, the liquid, unless frequently used, is very apt to cause the stopper of the bottle in which it is kept to become fixed. In fact it must be spoken of as an inconvenient liquid to keep for only occasional use.

Dr. Pavy had long felt that it would be very desirable if the ingredients of the test could be incorporated and kept in a solid form; and some years ago a fruitless attempt was made to attain this object. Latterly he had given his attention afresh to this subject, and the test-pellets before the Society were the result of the task undertaken. He need not enter into details regarding the ideas which failed on application to yield a satisfactory result. It would suffice for him to say that the test-pellets contained the solid ingre-

dients of the cupric test solution in a dry state, and that they were brought into the condition of a coherent mass by compression. The preparation had been placed in the hands of Mr. Cooper, of 26 Oxford Street, who, it was but justice to say, most successfully met the difficulties that were unexpectedly encountered. An article had been produced which met with Dr. Pavy's entire satisfaction, and which he felt was adapted hereafter to render good service in relation to diabetes.

There appeared no reason why the pellets should not keep for an indefinite time, without undergoing change, if preserved in a closed bottle away from moisture. In using them all that was necessary was to place one in a test-tube with about 3 c.c.—or rather under a drachm—of water, and to apply heat until complete solution had occurred, with the accomplishment of which a clear deep blue liquid would be formed, which actually constituted the cupric test solution. At present it was only as a qualitative test that the pellets were introduced, but there was no reason that hereafter the preparations should not be conducted with sufficient attention to accuracy of weighing to render them applicable for quantitative analysis. Dr. Pavy further mentioned that the test-pellets exhibited were ready to be sold by Mr. Cooper, in bottles containing twenty-four, at a cost of one shilling.

#### THE TREATMENT OF ASTHMA AND HAY FEVER.\*

##### TREATMENT OF ASTHMA.

At the end of our last lecture we were referring to the means by which asthmatic attacks could be relieved. I had spoken to you of the smoke of dry stramonium leaves, and told you how it was to be breathed. Another thing that is used a good deal for the same purpose is what is called niter paper. A piece of bibulous paper is dipped into a solution of nitrate of potassa, dried and then dipped in again once or twice until it becomes pretty well filled with the niter, then it is dried, and a piece of this as big as your two fingers is burnt, and the person suffering from the asthma incloses himself with a cloth or blanket and breathes the vapor of it. This relieves a good many persons. There is still another thing which seems as far as we yet know to be more efficacious, more prompt in its action, than any that has been before used for the purpose, and that is the inhalation of the nitrite of amyl. It has been used only a few years, was first used in one of the lunatic asylums in England as against epilepsy, and it is now stated that if a person who is subjected to epileptic attacks can be made to breathe the vapor of the nitrite of amyl before the convulsion is fairly formed; if for example he has an aura (as some persons have a sensation called by this name, which precedes by a minute or so the epileptic attack), and when this occurs he breathes this vapor, it is said that the convulsion does not occur; that the disease for that once is aborted. I have not had an opportunity to try it. It is easily arranged in this way: let the patient carry five or six drops of the nitrite of amyl on a sponge in a small vial; when he has notice of the coming attack let him instantly take the vial out of his pocket, remove the stopper and place it to his nose. The patient with asthma can of course use it in the same way. When an attack of asthma comes on, by breathing the vapor of, say five drops of this substance, it is said the attack will be stopped at once. But it does not cure the tendency to a recurrence. This affection is one that is apt to return at various times, sometimes frequently, sometimes at long intervals, and having once occurred it is almost sure to return unless that return can be prevented by one or another of the means I refer to.

As a radical cure for asthma there is but one medicine that I know of that has any reputation, and that is the iodide of potassium. This given with moderate freedom has in a considerable number of instances in which I have administered it, brought complete and permanent relief. I used to say, some years ago, that it would cure about one in six; of late years I have increased that proportion a good deal. I think now that it cures one-half of those who take it. It prevents the return of the attacks. How it operates I do not know, but, in all probability, upon the nervous system in some way. The only other means is a change of residence. There are certain places where particular people are specially liable to asthma, and other people may not be liable to it in the same place. A place which will give relief to one will not to another, so capricious is the affection. And yet there is in all probability a place somewhere in the world where every asthmatic can find relief, in which the disease will not return. Dr. Salter published a book on asthma a few years ago, and said that he found the choice place to be the smokiest part of smoky London, sending the patients into the center of the city where the smoke is the densest; there his patients did best. But we have not found that Pittsburg, or Cincinnati, or any of our own smoky towns will answer the same purpose. But, as I have said, there is a place somewhere where almost every person can get relief. The difficulty is that the greater part of those who who are suffering from this affection are not in a condition to change their residence. The idea will be illustrated by reference to an unmarried lady and her brother, who made a family together. She was suffering very much from asthma, and I advised the man, who was a man of leisure, that they both travel from place to place until they found one where this disease would not recur; to stop for a time at the first pleasant village they came to, and if the asthma came to go to another, and so on, until they found a place where it would not return. They finally found a town in Indiana, where she finds herself entirely comfortable and free from the attacks. A great many New Yorkers have found relief on Long Island Sound. A gentleman of my acquaintance in business here found by accident that he had no asthma in Bridgeport, Connecticut. He retired from business, built himself a house in Bridgeport, and has lived there many years, free from asthma. But there are a great many other people suffering from asthma, who would not find relief by going to Bridgeport. The sea gives relief generally—not always.

Before leaving this subject, I will state to you that a special cause has been assigned to asthma, to influenza, and to some of the particular forms of catarrh that I have described. The creature that has been supposed to produce them is called the *Asthmatos ciliaris*. A Western physician made the discovery that this particular parasite caused asthma and other catarrhs. In 1873 he published an account of it in a German journal, and a German physician described a case or two in which it occurred. A Boston physician, however, was more in earnest about it; he had about a hundred cases, and published a paper on the subject in the

*Virginia Medical Monthly*. He classifies the thing. He gives it a place in the animal creation, and thinks it is one of the rhizopods. He sent some of his specimens to Dr. Leidy, of Philadelphia. The doctor put it under his microscope, and on careful examination published a paper in regard to it, with twenty-four illustrations, in which he says the *Asthmatos ciliaris* is nothing more nor less than some distorted specimens of the ciliary epithelium of the air tubes, and yet the Western physician found that this particular parasite brought forth living young. As it is, you observe, an important theory comes to naught.

##### HAY FEVER.

The next affection that I call your attention to is sometimes called hay asthma, sometimes hay fever, sometimes summer cold. It is an affection sufficiently common for almost everybody to be more or less familiar with it, whether professional men or not. It occurs generally at about the same season, or at about the same day of the year, varying but about two or three days. One friend of mine expected his summer cold, his hay asthma, as he called it, on the 18th of August, and it would come pretty certainly on that day, or within a day or two of it. Our own Dr. Sands is subjected to it, and he knows definitely when it will come, and he flies away from the city, and thus gets rid of it. It is a very distressing disease, but not a dangerous one. It occurs with redness of the eyes, with soreness of the throat, with a filling up of the nose by a swelling of the mucous membrane, and soon a pretty free discharge from the nose; a pretty free discharge from the eyes, also of tears or thin fluid. It extends down the throat like an ordinary cold, and attacks the bronchial tubes, causing a great deal of cough and more or less weakness in its progress. Its duration is for several weeks, and finally it seems to get well of itself when its cause has ceased to operate.

Medicines have very little effect upon it. It produces a moderate fever in some persons, nothing, however, to require particular attention. This hay asthma is not an asthma at all. It has not the first quality of an asthma. It is a catarrh, a bronchitis, an inflammation of the eye and of the mucous membrane of the nose and of the air passages. In some persons it is severe enough to make them really sick; to compel them to keep their house, if not their bed; but the great majority are able to be about their affairs, to attend to their business during its continuance. This disease is said to be caused by the pollen of the plant designated in botany by the sounding name of *Ambrosia artemisiifolia*, vulgarly known as hog-weed, that grows in all the old fields in this part of the country. In walking through these fields the pollen of it collects about the legs of our trousers as we brush against it. You might call this affection the ambrosial disease, and yet I doubt whether Jupiter ever had it with all his ambrosia.

Relief from this is to be obtained by getting out of the reach of the pollen of the ambrosia; otherwise the person must suffer on, as long as the poison is being conveyed in the air he breathes. This pollen finds its way into cities—not so abundantly as in the country—but abundant enough to cause the inflammation that it is supposed to produce. Dr. Morse, of Paterson, made observations a few years ago in regard to it. He had some microscopical slides moistened with glycerine and exposed to the wind, and found that the glycerine became pretty fully studded even in the city with the pollen of this particular plant. At present I think the most accredited view is, that this hay fever is produced by the pollen of more than one plant. Not all who are subjected to hay fever have it at the same time of year. In some it occurs as early as July; in others, in August, in others, in September. In hardly any after September, perhaps in none. A friend of mine in the profession got the idea that the flower of the alantus produced asthma in his sister, and when the flowering of the tree was to take place he sent her into the country, where he supposed there was none of the alantus, and she had her attack as usual. He went to see her, and passing her bedroom window, found an alantus tree right by the house, where she had been as much exposed as if she had remained in the city. He tried another place, taking care to choose one where the tree did not grow, and there she did not have the summer asthma, so that there are at least two plants that may be charged with producing this disease in certain persons.

As to substantial relief, it is to be obtained, as I have said, almost solely by a change of locality, going out of the reach of the poison that produces it. Yet some relief is said to be produced by moistening the nares with a weak solution of quinine, and protecting the air passages by inhaling a spray of the same kind of solution. But, after all, the only substantial relief, I imagine, is to be obtained not in medicine, but in getting out of the way of the poison. There are a good many regions in this country where this pollen is not found, or at any rate, where the summer cold does not occur. Almost the whole of the White Mountain region is of this character. Persons having the affection going into this region in a few days get entire relief from it. The greater number of those who go to Fire Island, which is about nine miles from the coast of Long Island, for relief, get it. There are some mountain regions of Pennsylvania that are free from it, as well as a good deal of the mountain country of the West, and the shores of Lake Superior. So much, then, for hay asthma, which, as I said, is not an asthma, but a catarrh, a bronchitis.

#### OBSCURE DEVELOPMENT OF ABSCESS OF BRAIN.

DR. A. STEINACH, of this city, writes to the *Medical Record*: "In June of last year a case of brain disease came under my care, which I think in different regards very interesting, and well worthy to be reported. A boy of nine years commenced to vomit after breakfast, and soon after strabismus of the left eye appeared. These symptoms led me to suspect an affection of the brain, and I inquired if the boy had fallen on the head, or received a blow. The mother told me that during last winter, in January or February, her son had been skating on the sidewalk, and had fallen and struck his head on the ice; cold water had been applied, after which the headache disappeared. There had been no bleeding by the nose nor ears. As the remedies against the vomiting had not much effect, the mother went with the patient into the country during the hot season. There the vomiting was less frequent, as the patient lived principally on milk and eggs. After his return to the city the vomiting became again more frequent, and the symptoms of double vision manifested itself; although, by the course of the disease, I was convinced that the boy suffered from a lesion in the nerve-centers of vision. I advised the parents to obtain the opinion of Prof. W. A. Hammond. After careful examination, with the aid of the thermometer and ophthalmoscope, he pronounced the case one of commencing meningitis, due probably to the fall of the patient. The proposed

\* A lecture delivered at the College of Physicians and Surgeons, New York, by Alonso Clark, M.D., LL.D., Professor of Pathology and Practice of Medicine. Reported for the *Medical Gazette*, and revised by the lecturer.

remedies were again applied, but to no effect; the symptoms became more and more aggravated, until, in the middle of November, the boy was seized with convulsive spasms. These were arrested by a hypodermic injection of morphine into the arm. Up to this time the patient suffered no diminution of sensibility or mobility in any limb, and there was no difficulty in speech. It was accordingly to be presumed that neither the great hemispheres nor the medulla oblongata was implicated in the morbid process. Soon, however, the aspect changed. The iris dilated, sensibility became weaker, and, after lingering in a half comatose state for a few days, the patient died on the 26th of December. An autopsy was permitted and made twenty-six hours after death. The scalp was removed and an examination of the skull made, but no traces of an inflammation from any bruise were detected. The cortical substance of the hemispheres was in a moderate state of venous congestion. At the base of the brain, between the dura mater and arachnoides, was a moderate quantity of serum; such liquid was also found in the ventricles after incision of the corpus callosum. The surface of the thalamus opticus of the right side showed, in comparison with that of the left side, a grayish, injected color. It was softer and uneven. An incision into that substance opened an abscess of considerable size, comprising more than half the body of the thalamus. Two tablespoonfuls of pus-matter mixed with softened brain-substance could be removed; parts of the right hemisphere, especially in the neighborhood of the thalamus, were also inflamed and softened. The organs of the left brain were in healthy condition. We may now ask, Was the development of this abscess really the consequence of the fall of the boy during last winter, or must another yet unknown cause of it be sought for? An effusion and deposition of lymph may take place in consequence of a fall, and lie embedded under the arachnoid, if the quantity is very small, without producing serious symptoms for a long time. 'Effusion and deposition of lymph,' says Dr. Jonathan Hutchinson, of London, in a lecture on inflammation at the base of the brain, 'is always found in the greatest quantity where the arachnoid bridges over the largest spaces, as, for instance, at the base of the brain.' Large spaces are bridged over, particularly between the nerve-centers of the middle brain, and from the hemispheres to the former. It may then require a long time until from the spot of the lymph-deposit an abscess is formed, which, by growing larger and larger, produces also more serious symptoms, and determines more clearly the individual diseased organ."

#### ON AN UNUSUAL CASE OF ELECTROLYSIS.

By J. W. MALLETT.

A GALVANIC battery of six couples, of Smees' construction, the flat rectangular plates about 15 by 7 centimeters, was frequently used, in connection with an induction coil, for lecture-table purposes. When not required in action the plates, all attached to the same wooden frame, were raised from the divided stoneware trough by cords wound upon an axle, and kept suspended above the acid by means of a ratchet-wheel and pawl. The two terminal copper wires were generally coiled loosely together, so as to be out of the way when the battery was thus set aside.

On one occasion the apparatus was carried from the lecture-table to an adjoining room, the plates having been raised out of the acid, and it remained unnoticed for two or three days, when I perceived that the pawl had slipped from its place and the plates had fallen down and were fully immersed in the acid liquid—originally consisting of about one part, by weight, of sulphuric acid to seven or eight of water, but to which some additional strong acid had afterward been added by pouring directly into the cells when, during a lecture, the action was found insufficient, the apparatus having been used at intervals for some time. This additional acid was not accurately weighed or measured, but was poured in, as far as could roughly be guessed by the eye, in equal quantity into each cell. On emptying the trough, and washing off the plates, those of zinc were found much corroded, and it was noticed that one of the sheets of thin platinized silver foil lying between them was quite stiff and very considerably thickened. Detaching it from the rest—it belonged to the third cell from one end, or fourth from the other—I found that the surface on both sides was thickly coated with metallic zinc. By immersing it in pure dilute sulphuric acid in a beaker 14 818 grm. of zinc was removed, and then, the solution taking place slowly, connection was made with the negative pole of a small galvanic battery, and an insoluble opposite electrode from the positive pole immersed in the same beaker of acid, when 15 763 grm. more was removed; so that, the silver foil being now clean, 30 575 grammes altogether of zinc had been taken from its surface.

Obviously the condition of the liquid had not been quite the same in all the divisions of the trough, the acid having been of different strength; doubtless, as the plates lay neglected in it, it had first become completely converted into zinc sulphate in this particular cell, in which subsequently, the circuit being closed by the loose contact of the terminal wires, the chemical action of the battery had transferred itself from hydrogen sulphate to zinc sulphate, this becoming a "decomposing cell," and metallic zinc was electrolytically thrown down from the strong solution of its salt.

Although the explanation of the fact is simple enough, its actual occurrence is new to me. Such an accident may have often been observed, very probably by telegraph operators or electro-platers, but, if so, I have never seen any notice of it. It seems, therefore, worth a passing mention.—*Amer. Chem. Journal*.

#### THE RECLAMATION OF BOG LAND BY THE GERMAN METHOD OF BURYING WITH GRAVEL.

By PROFESSOR F. H. STORER.

For a dozen years or more a good deal of attention has been given in Europe to a peculiar method of cultivating bog land, which seems to have originated upon the great moors of North Germany, but which is manifestly applicable in many other localities, particularly in cold or temperate climates. This process has been occasionally referred to in American publications, and a brief account of it suggested by Prof. Playfair, of Edinburgh, was printed in the report of the U. S. Commissioner of Agriculture for 1877. In the same year some highly interesting chemical examinations of old fields, that had been cultivated in the manner now in question, were made by a chemist named Oswald, whose results deserve the careful attention of every intelligent farmer.

The fundamental idea of the German method is to cover the bog earth with a deep layer of gravel—after means have

been provided for draining the land—and to leave this gravel permanently as a surface layer, which is never to be mixed with the bog earth which lies beneath it. Upon this gravel the crops are grown, as will be explained directly. The gravel surface shields the young crops from destruction by night frosts in the spring; it lessens the evaporation of water from the soil and the radiation of heat, also, and so keeps the land comparatively warm. Moreover, as practical experience has shown, the buried humus can still supply the crops with food.

The layer of gravel might, of course, be brought to the bog in carts or sleds from hills or pits, in case that plan should happen to be convenient. But upon the great level moors of Europe, where the process originated, there was no alternative but to get the gravel from beneath the moor earth. It happened, withal, that the excavations made for gravel could readily be put to use as ditches to drain the land.

As explained by Rimpau, to whom the original description of the processes is commonly accredited, there are two general methods of lifting the gravel, one of them applicable to cases where the beds of humus are deep, and the other to the case of shallow beds. Where the layer of black earth is from a foot and a half to three feet thick, or more, the operations consist in digging large, deep ditches at stated intervals, and spreading upon the surface of the moor the sandy or gravelly subsoil which is taken from the bottoms of the ditches. In Rimpau's practice, the ditches are dug at distances of about 75 feet, one from another; they are 16 feet wide at the top, 11 feet wide at the bottom; and 4 or 5 feet deep. The black earth from the ditch is spread upon the surface of the moor, and then the sand or gravel or clay taken from the bottom of the ditch is spread in its turn, so that a layer of it about 4 inches thick shall everywhere cover the moor earth. A gravelly sand is held to be best; and, in general, the more gravelly the material is the better, though it is well to have a small proportion of clay in it. Pure, fine-grained quartz sand does not answer nearly so good a purpose as gravel. Oats may be sown at once upon the gravel, and afterward potatoes, roots, grain, and all kinds of forage crops.

The gravel layer is left permanently upon the surface of the land. It is never plowed under or mixed with the moor earth. But, from time to time, when the surface land becomes hard or incrustated, it is worked with a subsoil plow in such wise that the soil may be loosened without mixing one layer of it with another. It is well, however, in preparing the field at the beginning, to plow a little of the sand or gravel into the upper layer of black earth, so that there may be good capillary connection between the moor earth and the final layer of gravel. Some writers have argued, also, that it is well to sweeten the moor somewhat, by burning, before proceeding to spread the gravel upon it. The objection to fine sand, just mentioned, is not only that it is liable to be blown away by the wind, but that it dries out too rapidly and chills off too quickly by night. Indeed, one advantage of the method is, that the gravel layer compresses the drained moor earth, which would be apt to become too light and dry if it were cultivated in the ordinary way and exposed directly to sun and wind. Another objection to pure sand is, that its particles lie too close together, so that a thick layer of it would, when moist, hinder the proper access of air to the humus.

It is still an open question, perhaps, whether this burying process is the most economical method of reclaiming moor land, but there is no longer any room for doubt that it is a method of very great merit. It has been found in practice that the effects of the reclamation are sure and lasting, and that better crops can be got from the moors in this way than by any other known process.

The most interesting feature of this system of husbandry is the readiness with which crops get their nitrogenous food from the buried humus. Analysis of plants grown on the gravel layers has shown all along that the crops taken from moor land thus reclaimed are particularly rich in nitrogen; and after some years' experience, it began to be noticed by the farmers that grain crops are apt to lodge badly on reclaimed fields that are eight or ten years old. On critical examination it appears that the trouble is due to the extreme fertility of the soil, which had not been properly appreciated.

In the beginning, Rimpau's practice was to manure the gravel layer, much in the same way that he would have manured an upland field. But it appears that in so doing he made a grave mistake, for by using stable manure he got too much humus and too much nitrogen into the gravel layer. Oswald's examinations of the soil from reclaimed fields of various ages, from two to twelve years, have shown that the gravel of the older fields have become very much charged with organic matter. Not that the gravel had become mixed with moor earth from below; on the contrary, the line of demarcation between the moor earth and the gravel was surprisingly sharp, considering that twelve years had elapsed in some instances since the gravel was spread, and that arable crops had been grown upon the land continually. The only trouble was that the continued application of stable manure and the accumulation of plant roots, through injudicious shifts in the rotation of crops, had led to an accumulation of humus in the gravel. No very great quantity of nitrates was detected in these old fields. But there was an abundance of ammonia; and it was plain that there was present in the soil a far larger quantity of active nitrogenous manure than there was any need of, or, indeed, than was good for some kinds of crops, as the lodging had already shown.

Instead of being exhausted by cropping, the reclaimed fields had actually become too fertile. They were no longer competent to grow so great a variety of crops, at any given moment, as they had been at first; they still did very well for grass, however. Some of the twelve-year-old fields yielded the best crops of ray grass, cut over and over again for green fodder, they had ever given, though they had previously been well manured with dung, with superphosphate, bone meal, and Stassfurt potash salts.

Speaking in general terms, the continued use of dung upon these fields was a great error. Here, assuredly, if anywhere, the exclusive use of mineral fertilizers will be in order. Here, if anywhere, the farmer may put his trust almost exclusively in the great store of nitrogen which the humus can supply. It has, indeed, been found best, in practice, to use a little nitrate of soda, in conjunction with the mineral manures, at the beginning of the process of reclamation, before the moor earth has fairly begun to decompose. But there is little or no need of this nitrogenous adjunct subsequently, since the mere oxidation and decay of the humus supply enough nitrogen for the support of most kinds of crops.

It remains to be seen whether, after very long-continued

cultivation, the accumulation of humus in the gravel layer will be large enough to preclude the growing of grain crops, or to necessitate the laying down of another gravel layer, at enormous expense. But for the present it is plain that pains must be taken to work against the accumulation of humus, both by avoiding the use of organic manures, and by growing a proper proportion of exhaustive crops, so as to bring down the exuberant fertility and to promote the destruction of the unwished-for humus.

The other method of lifting gravel, alluded to at the beginning of this article, is with plows. It is used upon moors which have only a thin layer of black earth. When the moor earth is no thicker than from 8 to 16 inches, Rimpau gets his top layer of gravel or sand by throwing up the subsoil from below by a system of trench plowing. He runs three plows, specially adapted to the purpose, one after the other. The first plow turns a flat slice, 3 inches or so deep, of 13 or 16 inches; and the third plow throws up at least 6 inches of the loosened subsoil to cover the inverted soil. These plowing operations are carried on in summer and autumn. Next spring the furrows are leveled with a heavy harrow, and oats are sown. As was said before, it is to be understood that the moor must be well drained before it can be cultivated in this manner.—*Rural New Yorker*.

A CATALOGUE, containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office.

### THE Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, \$5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, \$2.50, stitched in paper, or \$3.50, bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, \$7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,  
37 Park Row, New York, N. Y.

#### TABLE OF CONTENTS.

I. INTERNATIONAL EXHIBITIONS, ETC.—The Melbourne International Exhibition. 1 illustration.	241
Applied Science Exhibition, Paris. Mining and metallurgy.—Machinery.—Building.—Lighting and heating.	241
Modernized Version of the "Old Oaken Bucket."	241
A Colorado Glacier.	241
The Reclamation of Bog Land by the German Method of Burying with Gravel. By Professor F. H. STORER.	241
II. ENGINEERING AND MECHANICS.—Balancing Pulleys and other parts of Rotating Machinery. By HUBBELL. An extremely important practical paper. 15 figures.	241
Hollow Plates. Abstract of Mr. HUTCHINSON'S paper on "Improvements in Machinery for Rolling Iron and Steel Plates." 3 figures.	241
On the Hardening, Tempering, and Annealing of Steel. Reports to Research Committee of the Institution of Mechanical Engineers. 1. Nature and composition of steel and cast iron.—2. Quantity of carbon in steel and cast iron, and its state.—3. Substances other than carbon entering into the composition of steel.	241
An American Cotton Mill. Description of the Great Scott Cotton Mills at Lowell, Mass. Motive power.—Belted.—Shafting.—Signaling.—Boilers.—Sizing.—Cotton house.—Improvements.—Products.—Repairs.	241
Shall we Have a Canal or a Railway? Remarks of Mr. HADG before the House Committee on Inter-oceanic Canal.	241
Electric Railway Brake. Boothby's invention. 2 figures.	241
III. ELECTRICITY, MAGNETISM, LIGHT, ETC.—Effects of a Thunder-storm on a Telegraph Line in New Zealand. By W. H. FLOYD, Superintendent New Zealand Railway Telegraphs.	241
Gas and Electricity in Paris. Comparative review of the system of public illumination in Paris, their cost and economy.	241
The Essential Nature of Electricity. By J. T. SPRAQUE.	241
Influence of Magnetism on the Tendency of Iron.—Method of research.—Results obtained.—Conclusions. 1 figure.	241
Recent Eclipses of the Sun.	241
On Actinometers. (Continued from No. 220). 9 figures.	241
On an Unusual Case of Electrolysis. By J. W. MALLETT.	241
IV. TECHNOLOGY AND CHEMISTRY.—The Bleaching of Jute Yarn.	241
Progress of Industrial Chemistry. Continuation of Professor MALLETT'S review of recent important changes in the industrial applications of chemistry. SUPPLEMENT No. 214. Calcium acid phosphate.—Aluminum sulphate.—Iron and copper sulphate.—Iodine.—Potassium iodide.—Bromine phosphorus.—Carbon disulphide.—Arsenic acid.—Oxygen gas.—Organic chemicals.—Mechanical application of chemical manufacture in general.	241
Flint and Crystal Glass.	241
Cupric Test Pellets for Sugar.	241
V. MEDICINE, HYGIENE, ETC.—The Treatment of Asthma and Hay Fever. Dr. ALONZO CLARKE.	241
Obscure Development of Abscess of Brain.	241

## PATENTS.

In connection with the publication of the SCIENTIFIC AMERICAN, we continue to act as Solicitors of Patents, Caveats, Trade Marks, Copyrights, etc., for the United States, Canada, Cuba, England, France, Germany, etc. We have had **thirty-five years' experience**.

Patents obtained through us are noticed in the SCIENTIFIC AMERICAN. This large and splendid illustrated weekly paper, \$3.50 a year, shows the progress of science, is very interesting, and has an enormous circulation.

Can I obtain a Patent? The quickest and best way to obtain a satisfactory answer, without expense, is to write to us (Munn & Co.), describing the invention, with a small sketch. All we need is to get the idea. We will immediately answer, and give the necessary instructions. For this advice we make no charge. We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured, with hints for procuring advances on inventions. Address

MUNN & CO., Publishers of the SCIENTIFIC AMERICAN,  
37 Park Row, New York.

